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THE CODORUS CREEK WASTEWATER MANAGEMENT STUDY. SUMMARY REPORT A--ETC(U)

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THE Codorus Creek WASTEWATER MANAGEMENT STUDY, Summary Report and Conclusions.

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See also Appendix A, Volume 1, AD-A036 853.

SUMMARY REPORT AND CONCLUSIONS

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AUTHORIZATION

Authority for the Codorus Creek Wastewater Management Study was given by the Congress of the United States in three separate documents: (1) the October 5, 1961 Senate Public Works Committee Resolution on the Susquehanna River Basin Comprehensive Study; (2) Public Law 89-298, the River and Harbor Act of 1965, which authorized the Northeastern United States Water Supply Study (NEWS); and (3) Section 235 of the Flood Control Act of 1970, Public Law 91-611.

The Senate Resolution called for the Corps of Engineers to provide:

> "a comprehensive plan for the development of the water and related land resources of the Susquehanna River Basin in the States of New York, Pennsylvania, and Maryland, in the combined interest of flood control, navigation, water supply, recreation, pollution abatement, and other beneficial water uses."[1]

Accordingly, the Susquehanna River Basin Study Coordinating Committee was created and the study to develop the plan undertaken. In July 1970, the Coordinating Committee published its final report. One of the specific recommendations of the Susquehanna Study's early action plan was that "survey scope studies be made of the potential for regional sewerage systems in . . . the Codorus Creek watershed, including York, Red Lion, Dallastown, Spring Grove, Penn Township, and the Greater York Area."[2]

In 1965, Congress authorized the Northeastern United States Water Supply Study (NEWS). This study directed the Corps of Engineers, in cooperation with Federal, state, and local agencies, to prepare "plans . . . to meet the long-range water needs of the northeastern United States."[3] It was explicitly stated that this plan "may provide for the construction, operation, and maintenance by the United States of . . . major purification facilities."[4]

Section 235 of the Flood Control Act of 1970 directed the Secretary of the Army, acting through the Chief of Engineers,

> "(a) . . . to investigate and study, in cooperation with the Administrator of the Environmental Protection Agency and other interested departments, agencies, and instrumentalities of the Federal Government and of the governments of states and their political subdivisions, the availability, quality, and use of waters within the Susquehanna River Basin with a view toward assisting in the preparation of a comprehensive plan for the development, conservation, and use of such waters."[5]

Section 235 further directed that the Chief of Engineers

> "(b) . . . shall make such studies and develop such plans as deemed necessary for the construction, operation, and maintenance of facilities in selected regions of the basin . . ."[6]

and that

> "(c) Such facilities may include, but shall not be limited to, water conveyance systems; regional waste treatment, interceptor, and holding facilities; water treatment facilities; and facilities and methods for recharging ground water reservoirs."[7]

Given these three mandates from Congress and the specific recommendation of the Susqhehanna River Basin Study, the Baltimore District of the Corps of Engineers began a comprehensive wastewater management study of the Codorus Creek Basin in late 1971.

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[1] Resolution of the Senate Committee on Public Works, October 5, 1961.

[2] Susquehanna River Basin Study, Supplement B – Program Summary, *page VIII-12.*

[3] Act of October 27, 1965, Title I, 79 Stat. 1073.

[4] Ibid.

[5] River and Harbor Act of 1970, Section 235, 84 Stat. 1834.

[6] Ibid.

[7] Ibid.

SYLLABUS

Problem Identification

The Codorus Creek Basin, shown in Figure 1, has an area of 280 square miles and is located in southeastern Pennsylvania, some 25 miles south of Harrisburg, Pennsylvania. It has a current population of 188,000 which is projected to grow to 323,000 by the year 2000. The major economic activities are the manufacturing and service industries, however, the character of the land is predominantly rural with much of it devoted to farming.

The Codorus stream system is severely degraded, with specific problem areas denoted in Figure 2. The system supports only two water uses, wastewater dilution and water supply. By 1985, if nothing is done, the available surface water will not be able to meet the water demand of the basin. To remove the man-made constraints on the Codorus and to free it for more productive use, measures must be undertaken to revitalize and renew this stream and its tributaries.

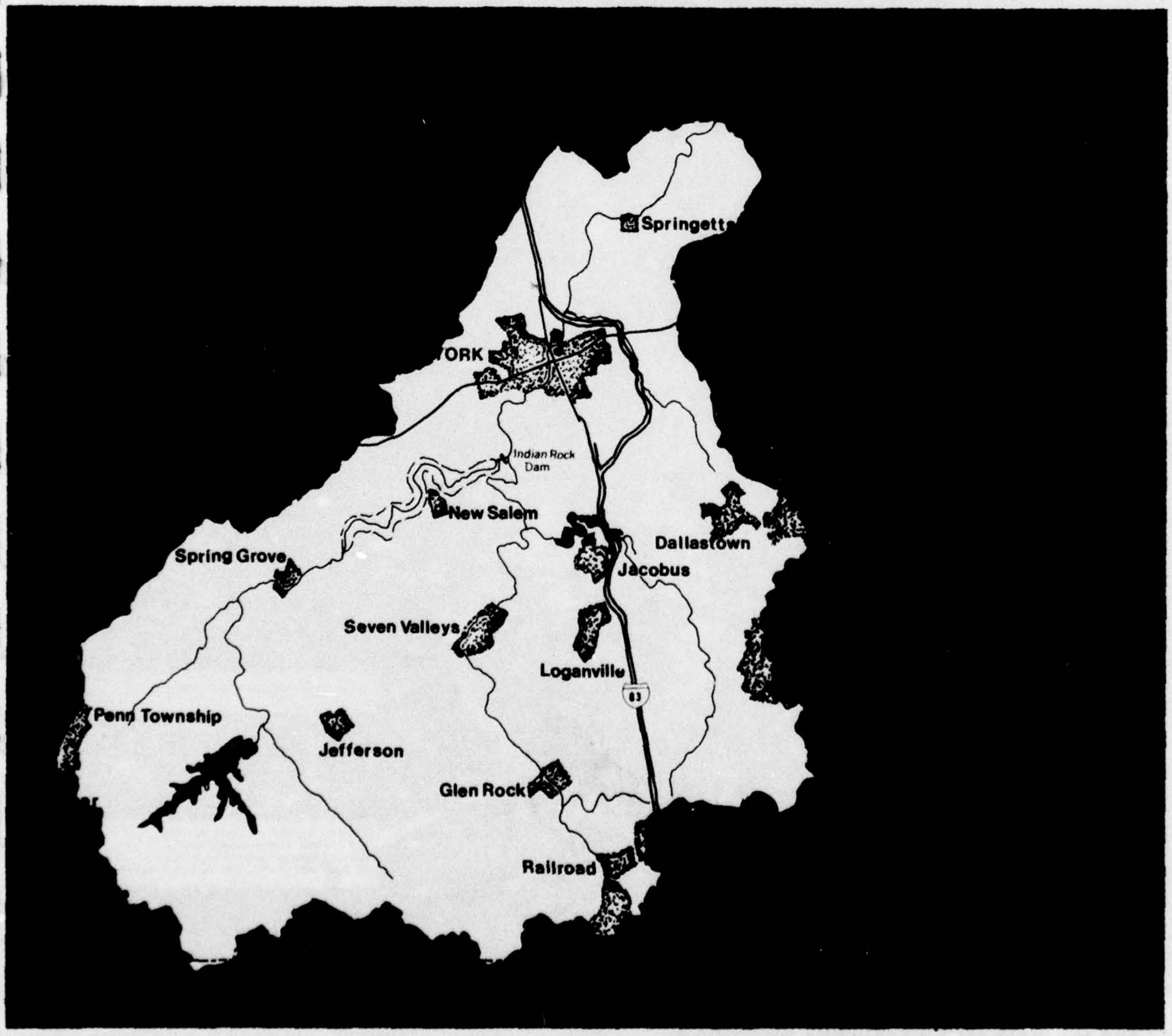


Figure 1. Codorus Creek Basin Study Area

Study Objective

The objective of the Codorus Creek Wastewater Management Study is to recommend those actions which are necessary to significantly improve the quality of the waters of the creek to the extent that they can provide a basis for the restoration of natural environmental values while simultaneously serving the economic and social needs of the people.

To achieve this objective, it was necessary to establish a series of goals. These are:

To formulate technical solutions leading to the definition of the term "significant improvement in water quality";

To keep open options for the future by displaying and carrying through the planning process a range of technical choice based on the concepts of water process treatment and land application treatment;

To promote, through comprehensive planning, the rational and integrated management of water resources; and

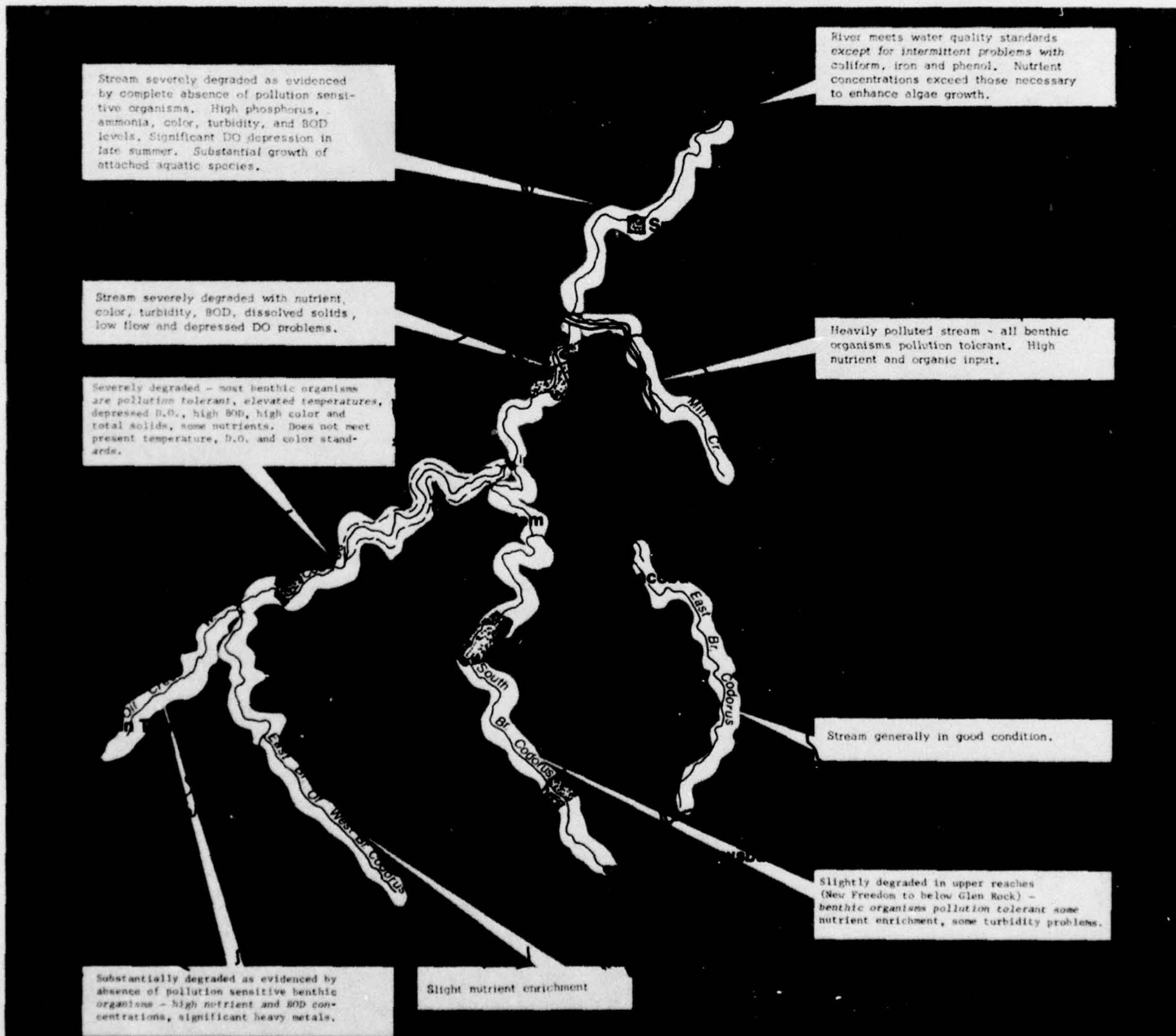


Figure 2. Existing Water Quality Conditions

To plan and provide guidance for the implementation of a wastewater management program.

Study Management

The Baltimore District of the Corps of Engineers had overall responsibility for managing the study. To insure sound, coordinated planning in a short time frame, a multi-agency study management structure, as depicted in Figure 3, was established.

The Policy Committee, consisting of representatives of the Corps of Engineers, the Environmental Protection Agency, the Commonwealth of Pennsylvania, and the York County Planning Commission, was charged with formulating policies on the conduct of the study and with providing guidance to the other two committees. The Citizens Advisory Committee, composed of representatives of concerned local organizations, represented the citizens of the study area throughout the study, providing a continuous link between the public and the Policy Committee. The Technical Advisory Committee, consisting of professional agency staff members and consultants, provided the engineering, economic, environmental, and other technical expertise necessary to gather, develop, and present data and to formulate technical alternatives.

The Planning Process

Planning in the Codorus Creek Wastewater Management Study incorporated two separate, but concurrent and complementary, processes.

The first process was the formulation of a plan, through screening and modification of alternative solutions, by the Policy Committee, with input from the Citizens Advisory Committee and the Technical Advisory Committee. This plan came to be known as the December Plan. Due to time constraints, the data upon which Policy Committee decisions were based were often not as complete as desired. Given this, it was possible that the December Plan might inadvertently foreclose future choices, which in light of more refined information could be superior to the December Plan.

To counteract this shortcoming, the other aspect of the planning process was to formulate two basic alternative solutions building on the fundamental advanced wastewater treatment technologies of land application and water process treatment. This portion of the planning process was the responsibility of the Corps of Engineers.

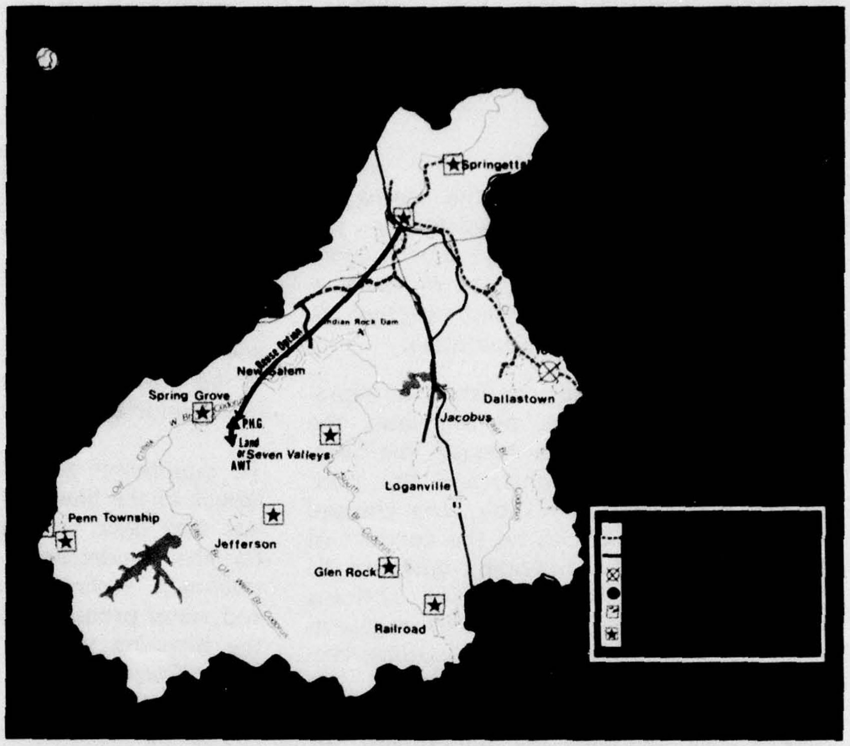
Though proceeding concurrently with the Policy Committee process, it was unaffected by screening and was continually refined as better data became available.

The output of the dual plan formulation process was "Alternatives For Choice," a range of technological alternatives which would provide for better evaluation by all and a more rational decision as to which alternative plan would be implemented.

Alternatives For Choice

Three plans are proposed which meet the study objective. A fourth plan is presented

Figure 3. Study Management Organization



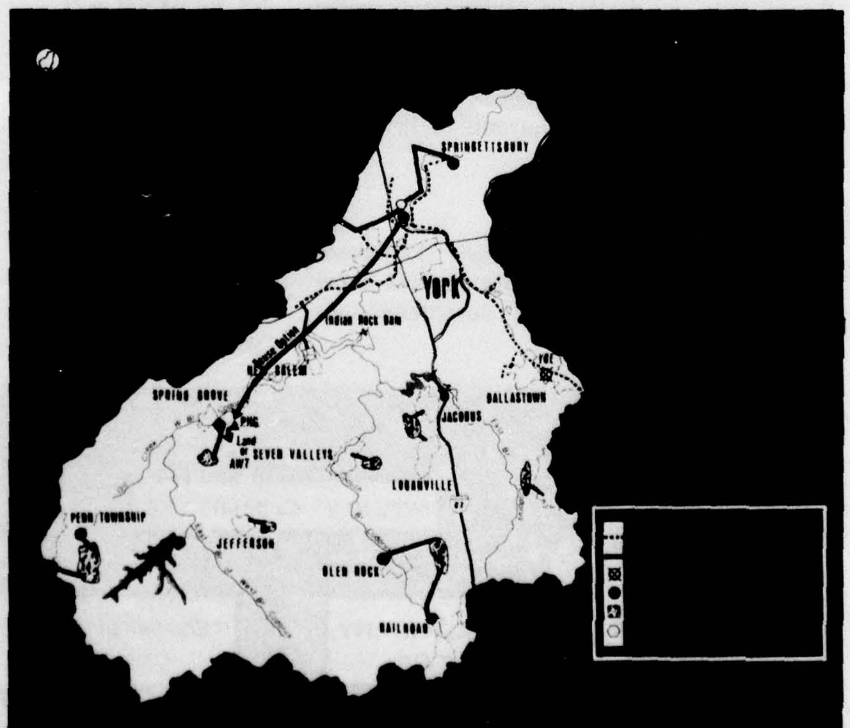
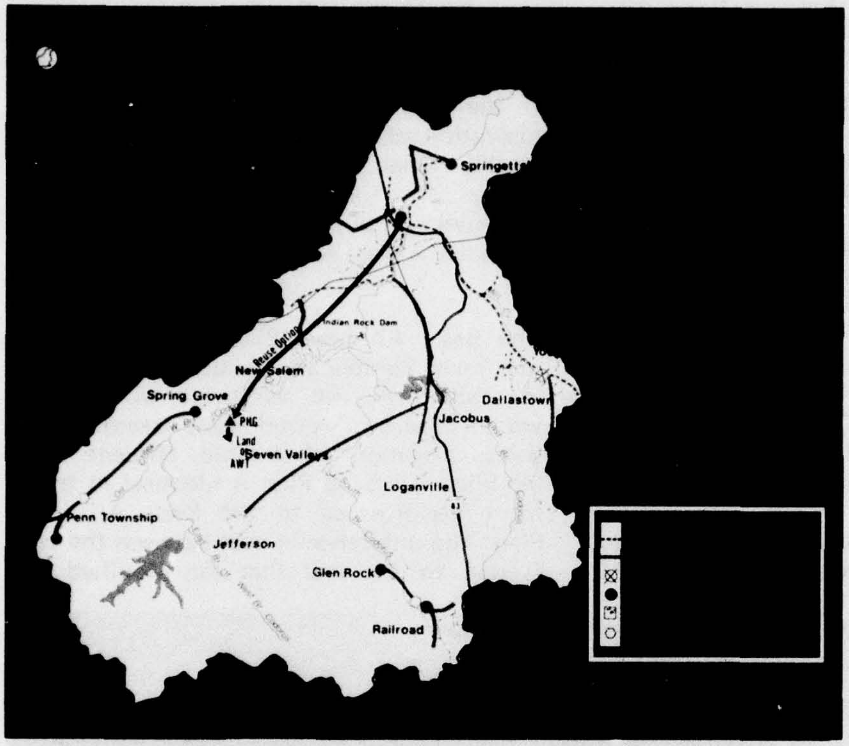


Figure 4. Alternatives For Choice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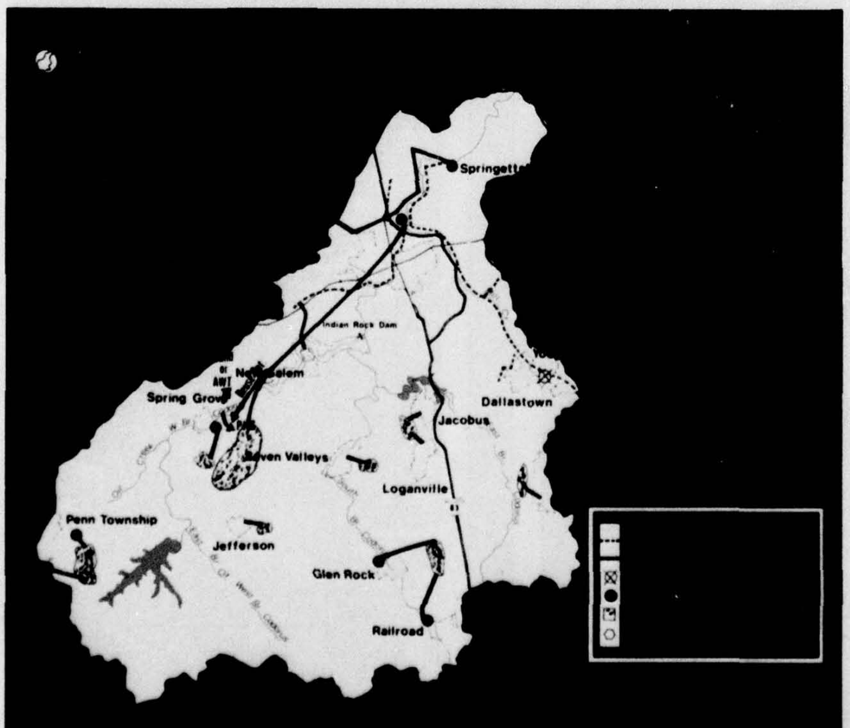
Reuse Option
New Salem
Spring Grove
PHG
Land or AWT
Seven Valleys
Jacobus
Dallastown
Loganville
Penn Township
Jefferson
Glen Rock
Railroad


Indian Rock Dam
or AWT
New Salem
Spring Grove
Seven Valleys
Jacobus
Dallastown
Loganville
Penn Township
Jefferson
Glen Rock
Railroad

which would meet the existing water quality standards. Collectively, these four plans are the alternatives for choice. They are depicted in Figure 4.

The plan which would meet existing standards incorporates the upgrading of existing or programmed sewage treatment plants in the study area. The treatment level attained by this plan would be well below that of the other three alternatives, particularly in nutrient removal. This plan, however, is the least expensive of all and would require little institutional change. The plan has an estimated capital cost of $30,543,000 and an estimated average annual cost of $4,699,000.

With the Basic All Water Plan all wastewater in the basin would receive advanced waste treatment in water process treatment plants. The Modified All Water Plan, which consists of the Basic All Water Plan with carbon adsorption added, provides for the maximum feasible water quality under existing technology. The Basic All Water Plan has an estimated capital cost of $75,680,000 and an estimated average annual cost of $8,961,000.

The Basic All Land Plan provides for the maximum feasible water quality under existing technology. All wastewater in the basin would receive advanced waste treatment via spray irrigation of treated effluent. The Modified All Land Plan is identical in treatment performance to the Basic All Land Plan. The difference in cost between the two is due to the fact that the Modified All

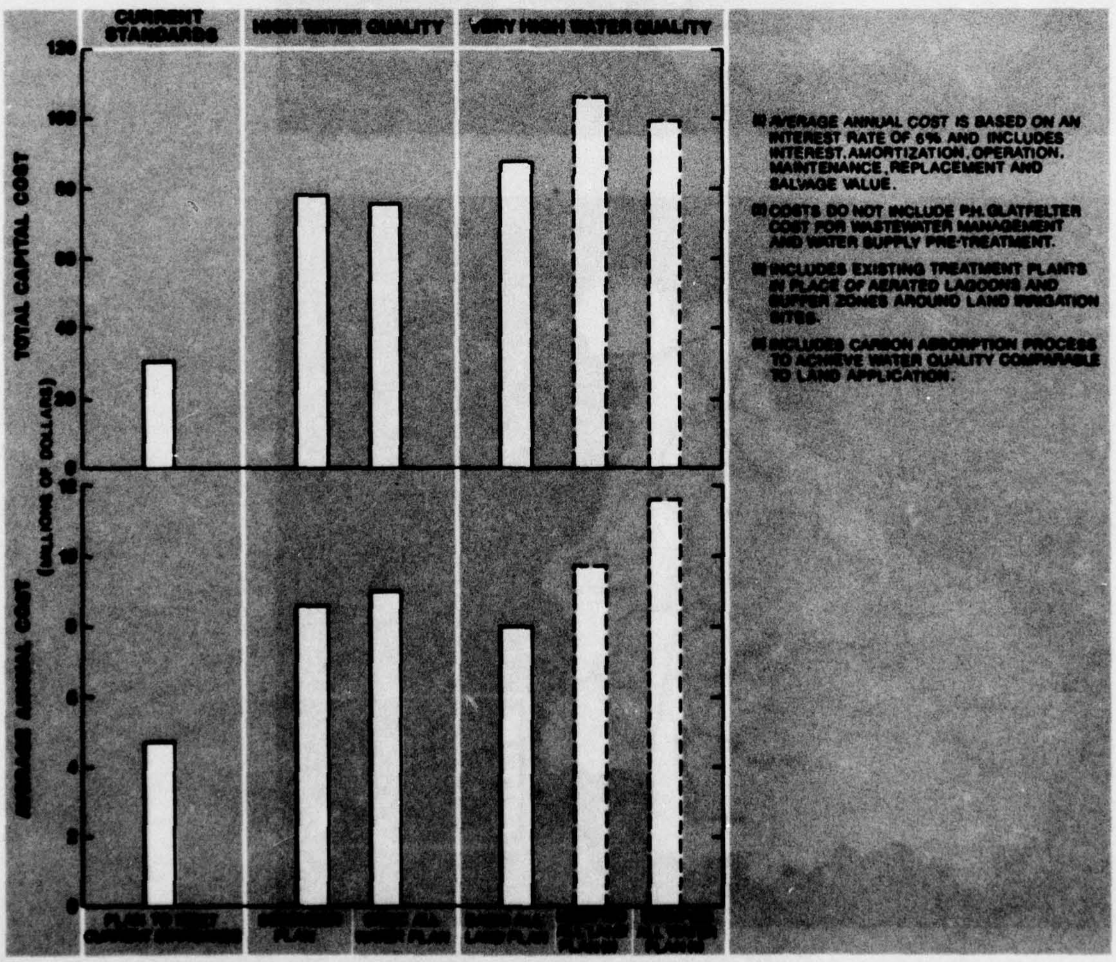


Figure 5. Cost—Performance Comparison of Alternates for Choice[1,2]

Land Plan retains all existing treatment plants and includes larger buffer zones. The Basic All Land Plan has an estimated capital cost of $87,833,000 and an estimated average annual cost of $8,044,000.

The December Plan, which was the plan developed by the Policy Committee and Citizens Advisory Committee, provides for the maximum feasible water quality under existing technology. Upper basin wastewater would be spray irrigated for advanced waste treatment; lower basin wastewater would receive advanced treatment by water process treatment plants. The December Plan has an estimated capital cost of $78,166,000 and an estimated average annual cost of $8,567,000.

Figure 5 presents a cost comparison of the four plans.

The acceptance of certain premise sets leads to definite conclusions regarding the plan which should be adopted. In capsule form, these premise sets and the conclusions they lead to are presented in Figure 6.

PREMISE SET 1

1. The increase of benefits of the study adopted water quality goals over the existing standards cannot justify the cost of such an increase.

2. The basic status quo for wastewater treatment should be retained.

CONCLUSION: PLAN TO MEET CURRENT STANDARDS

PREMISE SET 2

1. The adopted water quality goals of the study must be attained.

2. Existing wastewater treatment facilities must not be abandoned.

3. The adopted plan should have minimum land requirements.

4. Uncertainties due to lack of experience and knowledge relative to land application systems are sufficient reasons to reject this concept.

CONCLUSION: BASIC ALL WATER PLAN

PREMISE SET 3

1. The adopted water quality goals of the study must be attained.

2. Existing wastewater treatment facilities may be abandoned in favor of substantial cost savings.

3. Drought streamflow should be increased.

4. There is advantage to potential agricultural benefits.

5. The adopted plan should best complement other environmental programs.

6. Open space should be preserved.

7. The adopted plan should combine least cost with the most effective technical performance.

8. Departure from the basic status quo in wastewater treatment to land application is acceptable.

CONCLUSION: BASIC ALL LAND PLAN

PREMISE SET 4

1. The adopted water quality goals of the study must be attained.

2. Existing wastewater treatment facilities must not be abandoned.

3. There is advantage to potential agricultural benefits.

4. Open space should be preserved.

5. The features of water process treatment and land application should be combined without committing the region to either one.

6. Departure from the basic status quo in wastewater treatment to land application is acceptable.

CONCLUSION: DECEMBER PLAN

Figure 6. Premise Sets—Alternatives For Choice

Reuse

As shown in Figure 4, reuse is an option which is applicable to any of the alternatives for choice. Reuse embodies the concept of recycling wastewater to make it more productive and simultaneously freeing other water for beneficial uses, such as water supply and recreation.

The key to successful implementation of reuse is the P. H. Glatfelter Company, since this large manufacturer of paper products generates 59% of the industrial wastewater in the study area. Reuse would involve piping secondary treated wastewater to the P. H. Glatfelter plant where it would be used as raw process water for paper making. It would then receive advanced waste treatment by either water process or land application. Other industries in the study area could similarly be connected to the system.

To illustrate the potential economic benefits of reuse, Table 1 shows the estimated costs of the Alternatives For Choice with and without reuse.

A direct result of implementing the Reuse Option is an increase in the amount of available industrial water supply. The value of this water is not included or reflected in Table 1. The only beneficial effect of reuse reflected in Table 1 is the saving in advanced waste treatment costs resulting from reusing secondary (rather than tertiary) effluent. The entries in Table 1, therefore, provide the answer to the following question: "Does the saving in advanced waste treatment costs resulting from reuse offset the cost of adding the reuse facilities to the Alternatives For Choice?" Comparing the average annual costs with and without reuse in Table 1, it is evident that for each of the Alternatives For Choice, except the Plan To Meet Current Standards, the saving in treatment cost is greater than the cost of reuse facilities.

Similar to the discussion on the alternatives for choice, the acceptance of certain premises leads to the adoption of the reuse option, as shown below in Figure 7.

PREMISE SET 5

1. A wastewater management plan is desired that produces significant water supply benefits as well as other potential benefits in water resource conservation and use.

2. Both the York Urban Area and the P. H. Glatfelter Company recognize mutual benefits from implementation of the Reuse Option.

3. The cost savings offered by the Reuse Option are desired.

CONCLUSION: REUSE

Figure 7: Premise Set 5

TABLE 1 COST ESTIMATE: REUSE OPTION
(All Costs in $1,000)

Alternatives For Choice	Construction Cost		Average Annual Cost	
	Without Reuse	With Reuse	Without Reuse	With Reuse
Plan To Meet Current Standards	46,436	52,625	8,318	8,663
Basic All Water Plan	91,573	89,832	12,580	11,887
Basic All Land Plan	103,726	95,757	11,644	10,312
December Plan	94,059	92,319	12,186	11,493

NOTE: 1. Average annual cost is based on an interest rate of 6%, and includes interest, amortization, operation, maintenance, replacement, and salvage value.

2. All costs included P. H. Glatfelter costs for wastewater management and water supply pre-treatment.

Purpose of the Summary Report and Conclusions

This volume of the Codorus Creek Wastewater Management Study has provided alternatives for choice. A subsequent volume will present the findings of fact and recommendations of the Baltimore District Engineer. These will be based not only on the contents of this volume and its appendices, but also on the views of the concerned agencies on the study as well as the indicated desires of the public as reflected in the final Public Meeting.

Beyond this, the Summary Report and Conclusions provide a base document for decision at all levels on water quality systems for the Codorus Basin. While it was not the function of this portion of the Codorus Creek Wastewater Management Study to recommend actions, a function which will be performed by the companion document, nonetheless plans have been displayed herein which can significantly improve the quality of the waters of Codorus Creek to the extent that they can provide a basis for the restoration of natural environmental values while simultaneously serving the economic and social needs of the people.

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CHAPTER I STUDY OBJECTIVE

The objective of the Codorus Creek Wastewater Management Study is to recommend those actions which are necessary to significantly improve the quality of the waters of Codorus Creek to the extent that they can provide a basis for the restoration of natural, environmental values while simultaneously serving the economic and social needs of the people. In order to accomplish this, it will be necessary to evaluate and assess the impact of the water quality problems of the Codorus Creek Watershed and to analyze the technical and institutional solutions to these problems.

The objective of the Codorus Creek Wastewater Management Study is very broad. Efficient conduct of the study demanded that the objective be more precisely defined in terms of realistic goals. The first of these goals was to formulate technical solutions leading to the definition of the term "significant improvement of water quality." At the inception of the study, it was not possible to define precisely the term "significant improvement." Although there was no question about the desirability of removing all odor and color causing pollutants from the water, the elimination of these sensory pollution indicators suggested further technical questions such as: "What is the desired concentration of dissolved oxygen?"; "What is the optimum BOD concentration?"; and "What is the safe ammonia concentration?" Defining "significant improvement" hinged on articulating and adopting a desired treatment level for wastewater which, in fact, was done later in the study. Nonetheless, the goal of formulating technical solutions to define a significant water quality improvement meant, in its simplest form, cleaning up Codorus Creek. In this sense, it provided an overall direction and goal for the study. It was clearly known that the present water quality situation was undesirable.

Fundamental to the achievement of a significant improvement in water quality is the method by which this goal can be attained. However, the science of water quality control and improvement is by no means an exact one. Many facets of its technology, especially those relating to high levels of performance, are still in their infancy although proven in the pilot or small prototype stage. It was apparent that, even within

the extremely short time frame of the Codorus Creek Wastewater Management Study, there was a high probability of marked advances in technological knowledge taking place. To foreclose future options within this planning atmosphere would be extremely undesirable. Rather, final decisions on technological solutions would have to be reserved until the very latest stage of the study period.

Thus, a second goal was established, a goal which provided for keeping open options for the future by displaying throughout the study period a range of technological choice. This display would be based upon two fundamental concepts of wastewater treatment – water process treatment and land application treatment. This is not to imply that screening of alternative solutions would not take place. Rather, plan formulation would proceed in a normal manner. The difference would be that alternatives representing the two technological concepts would be carried through the plan formulation process, refined as additional knowledge became available, and used as a baseline for evaluating other alternative solutions. The final output of the study would then become a plan for solving the water quality problems of Codorus Creek – a plan which had been formulated in the light of cost-effectiveness, systems performance, and environmental and social impacts. But more important, future options would not have been foreclosed due to the fact that alternatives representing a range of technological choice had been carried completely through the planning process, evaluated in detail, and weighed against the selected solution.

It has been shown time and again in the water resource management field that resource uses are interconnected. Taking cognizance of this fact, a third goal was adopted for the study which provided for the rational and integrated management of the water resources of the Codorus Basin.

Water quality would not be viewed in the abstract, divorced from all other resource uses. Rather, consideration would be given as to how achieved water quality could complement and facilitate other water uses, such as water supply and water-based recreation. The view was toward achieving a total, as opposed to partial, resource management strategy – a strategy which would assist the residents of the study area in attaining a quality living environment.

The last goal was to design solutions such that they could be implemented. This meant that the real constraints and requirements of ongoing programs on the local, Commonwealth, and Federal levels had to be considered. It also required that the institutional situation in the study area would have to be weighed and modifications or new institutions proposed as appropriate. In effect, this goal assured that all alternative solutions would be considered in real world light and be viable plans to achieve clean water.

In summary, the objective of the Codorus Creek Wastewater Management Study is to recommend those actions which are necessary to significantly improve the quality of the waters of the creek to the extent that they can provide a basis for the restoration of natural environmental values while simultaneously serving the economic and social needs of the people. To achieve this objective, it was necessary to establish a series of goals. These are:

To formulate technical solutions leading to the definition of the term "significant improvement in water quality";

To keep open options for the future by displaying and carrying through the planning process a range of technical choice based on the concepts of water process treatment and land application treatment;

To promote, through comprehensive planning, the rational and integrated management of water resources; and

To plan and provide guidance for the implementation of a wastewater management program.

CHAPTER II STUDY MANAGEMENT AND PUBLIC PARTICIPATION

STUDY MANAGEMENT

Structure

It was desired that the Codorus Creek Wastewater Management Study provide for the incorporation of the views of all persons interested in working toward the improvement of the quality of the waters of Codorus Creek. Because of this, management problems were quite challenging. Not only were there the normal complexities associated with the management of a study staff, but also, the additional tasks associated with the management of coordination programs with other governmental agencies (Federal, state, and local) and the general public as well.

Primary responsibility for the conduct of the Codorus Creek Wastewater Management Study was assigned to the Baltimore District Engineer of the Corps of Engineers. He assembled a study staff consisting of experts in the fields of water resources planning, engineering, and the environmental, biological and social sciences. This staff's job was to coordinate all study activities, to collect all basic data, to perform all technical and environmental evaluations, to formulate alternative solutions using a wide range of technological concepts, to develop conclusions, and to prepare the final report.

It was realized that participation by other governmental agencies and the public would be difficult unless a formal vehicle was established for coordinating their efforts. Consultations were held with the Environmental Protection Agency and the Department of Environmental Resources of the Commonwealth of Pennsylvania in an effort to develop such a vehicle. As a result of these consultations, the organizational structure shown on Figure 8 was established. It consisted of a Policy Committee, a Citizens Advisory Committee, and a Technical Advisory Committee.

The key element in this system was the Policy Committee composed of representatives of the Corps of Engineers, the Environmental Protection Agency, the Pennsylvania Department of Environmental Resources, and the York County Planning Commission. This committee was responsible for formulating policies and its views and recommendations were the guidelines used by the Corps of Engineers in conducting the Codorus Creek Wastewater Management Study.

The Citizens Advisory Committee had a very important role to play in the study process. The integration of the viewpoints of all concerned citizens is a vital ingredient in producing an effective wastewater management program. Effective participation of all persons, however, cannot be accomplished by relying solely on large meetings; rather a selected group representing as wide a range of viewpoints as possible, which can speak in

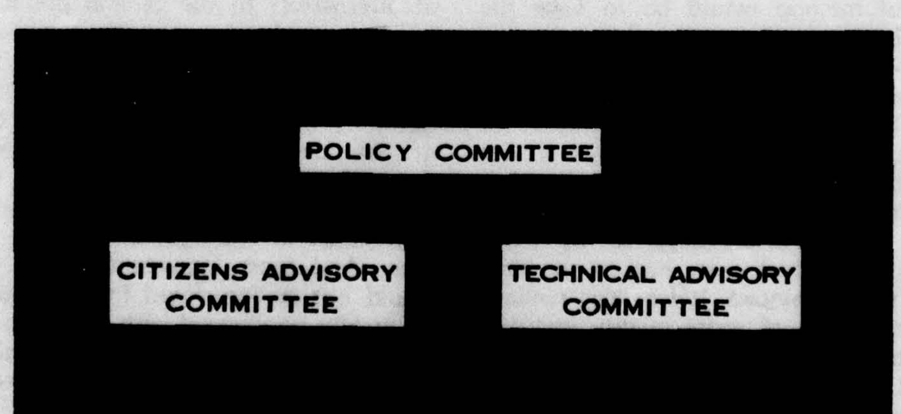


Figure 8. Study Management Organization

unison, appears to be an effective tool for communication with the citizen at large. The Citizens Advisory Committee was just this type of group. Through it, all concerned citizens were provided with an opportunity to make their views known to the Corps of Engineers and the Policy Committee and to obtain information relative to the study.

The Citizens Advisory Committee was established through the staff of the York County Planning Commission who developed a list of 12 *organizations representing* a cross-section of the Codorus Creek Watershed's population. Included were representatives from public service, industry, conservation, and political action groups.

The Technical Advisory Committee was formed to facilitate the exchange of technical informatoion relative to the study. This group consisted of representatives of the technical staffs of the Policy Committee members and private consultants retained by them. Throughout the study, this committee was active in furnishing technical information to the Policy Committee.

Mission

Once the Policy Committee and Citizens Advisory Committee were formed, there still remained the problem of how their views and preferences could be expressed most effectively. This could have been done in the form of comments resulting from a review of the work done by the Corps of Engineers' staff. It was felt, however, that a much more meaningful method would be to have the Policy Committee, in conjunction with the Citizens Advisory Committee, develop a plan of its own – a plan which would recommend actions for improving the quality of the waters of Codorus Creek. But it was realized that the time frame for the Codorus Creek Study was extremely short and that decisions would often have to be made based on data which were not, at the time of use, fully developed. It was also realized that many facets of water quality improvement technology are still in their infancy and that there was a high probability of marked advances in technology taking place during the study period. To force the Policy and Citizens Advisory Committees to make irretrievable judgments and decisions in this planning atmosphere was highly undesirable. Consequently, the previously mentioned planning concept was used, which provided the development by the Policy Committee and Citizens Advisory Committee of a plan for solving the water quality problems of Codorus Creek. At the same time, alternative solutions would be developed and refined which represented the two technological *concepts of advanced waste treatment, i.e.*, advanced wastewater treatment by land application and advanced wastewater treatment by water process treatment. Through this technique, final selection of a recommended plan could be deferred until the last stage of the study period.

One of the products of this concept of water resources planning would be "Alternatives For Choice." These were ultimately to take the form of four alternatives, i.e., one plan which had been developed by the Policy Committee and Citizens Advisory Committee (later called the December Plan), two plans representing each of the basic concepts of advanced wastewater treatment technology, and a fourth plan which provided for meeting present stream quality standards only. These "Alternatives For Choice" would provide the Policy Committee and Citizens Advisory Committee with the opportunity to review their past decisions in the light of fully refined data; the "Alternatives For Choice" would be invaluable in presenting detailed evaluations of alternatives to the general public for its reaction; and, as a result, the Baltimore District Engineer would have, as a basis for his final recommendations, the benefit of not only fully refined alternatives, but also of the carefully formulated recommendations of the Policy Committee and Citizens Advisory Committee – recommendations formulated in the light of the best possible data. And most important, future options would not be foreclosed for those who will ultimately be charged with the responsibility for implementing a plan for significantly improving the quality of the waters of Codorus Creek.

PUBLIC PARTICIPATION

Public involvement in the Codorus Creek Wastewater Management Study was accomplished through the use of public meetings, radio and television coverage, public handouts, newspaper articles, press releases, and most significantly the Citizens Advisory Committee.

Two public meetings were held, one in July 1971 and the other in February 1972. Both of these were sponsored by the York County Planning Commission. At the first public meeting, the Baltimore District Engineer explained the study in detail – the reasons for it, what it would accomplish, and how it would be performed. Approximately two hundred people attended this meeting and many of them participated in the discussion which followed. The significance of the meeting was that it not only set the stage for public involvement in the study, but provided feedback which disclosed an intense public concern for improving the degraded condition of Codorus Creek.

About 150 people attended the second public meeting. This meeting brought the general public up-to-date on the study's progress and presented findings of the Policy Committee. The public reacted favorably to the work which had been done.

Both of York's major newspapers carried articles on the Codorus Creek Wastewater Management Study. Radio stations provided coverage of the study progress and made announcements advising the citizens of the area of forthcoming public meetings. In January 1972, a local television station presented a 30 minute prime time program on Codorus Creek which featured the Baltimore District Engineer, the Chairman of the Citizens Advisory Committee, and the Director of the York County Planning Commission as guest panelists.

This report has already explained, in general, the role of the Citizens Advisory Committee. It should be noted here, however, that although public meeting attendance was good and newspaper and other media coverage was excellent, the ingredient which tied the public participation program together and made the public a real factor in the planning process was the Citizens Advisory Committee. In most cases, newspaper articles were based on information supplied through this committee, but even more important, by conscientiously representing the many and sometimes conflicting interests of the people within the study area, the Citizens Advisory Committee provided the Policy Committee and the study team with a continuing evaluation of the views and preferences of the people.

CHAPTER III STUDY AREA AND ITS PROBLEMS

STUDY AREA

General

The study is concerned with a geographical area focused on Codorus Creek, York County, Pennsylvania – a creek which is in need of environmental rehabilitation and enhancement through an improvement in the quality of its waters. What must be known about this area in order to accomplish this? The phenomena which have caused the need for this rehabilitation certainly must be ascertained. Further, an understanding of these phenomena must be sought so that corrective measures can be instituted – measures which will enhance the qualities of

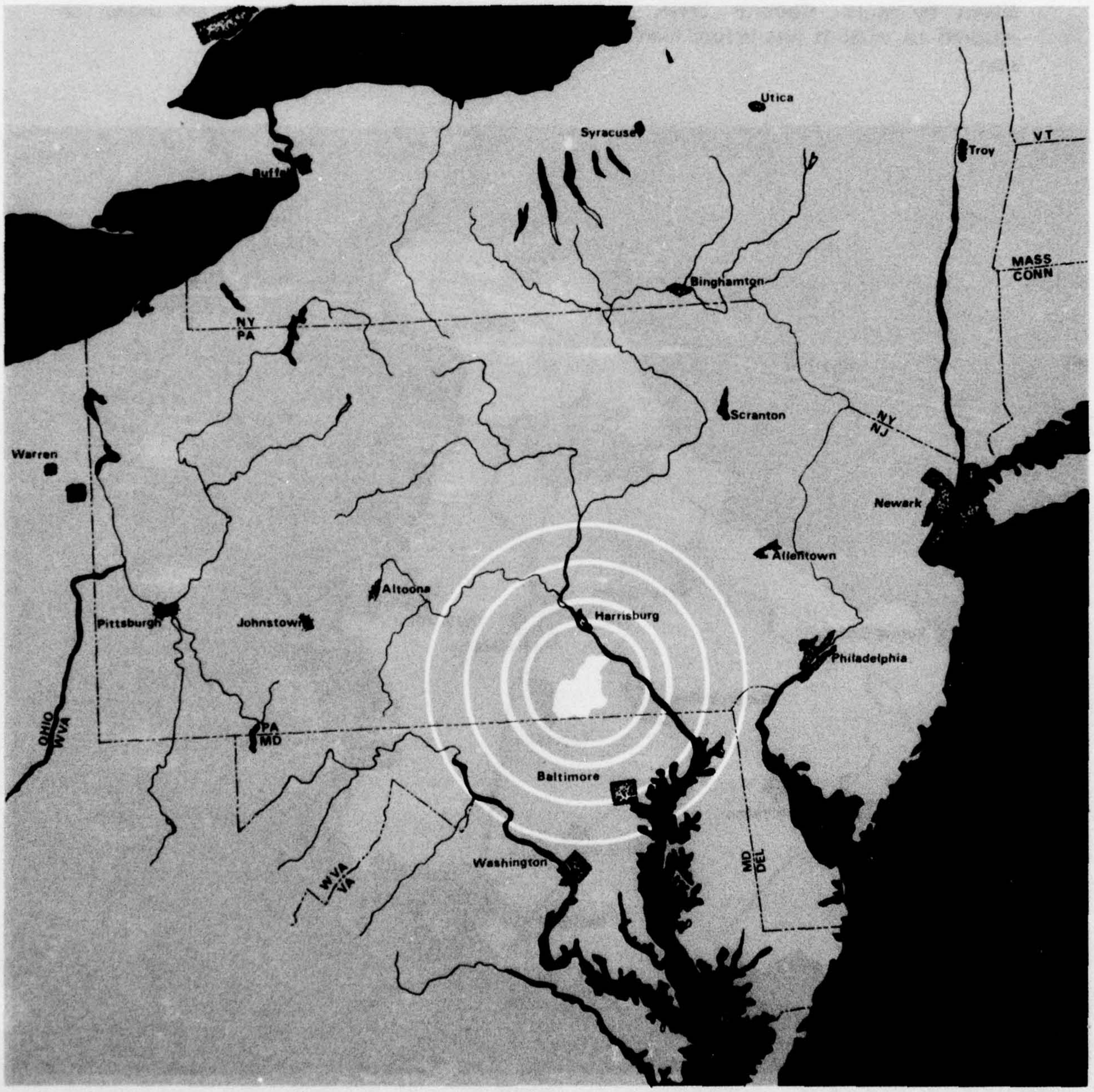


Figure 9. Study Area Location

the waters of Codorus Creek. As a first step, the characteristics of the basin must be inventoried – characteristics such as its physical limits, its land form, the density and characteristics of its population, the extent of urbanization, and the nature of its economic structure. The intent of this chapter is to provide an understanding of these characteristics – an understanding which will provide a basis for addressing the means by which Codorus Creek can be restored to what it was before man's intrusion.

Boundaries

The boundary of the study area for the Codorus Creek Wastewater Management Study is the ridge line of the Codorus Creek Watershed as modified by limits of urban development. It is bordered on the south by the Pennsylvania-Maryland State line and on the north by the Susquehanna River. The Codorus Creek Basin and the communities included in the study area are shown on Figure 10.

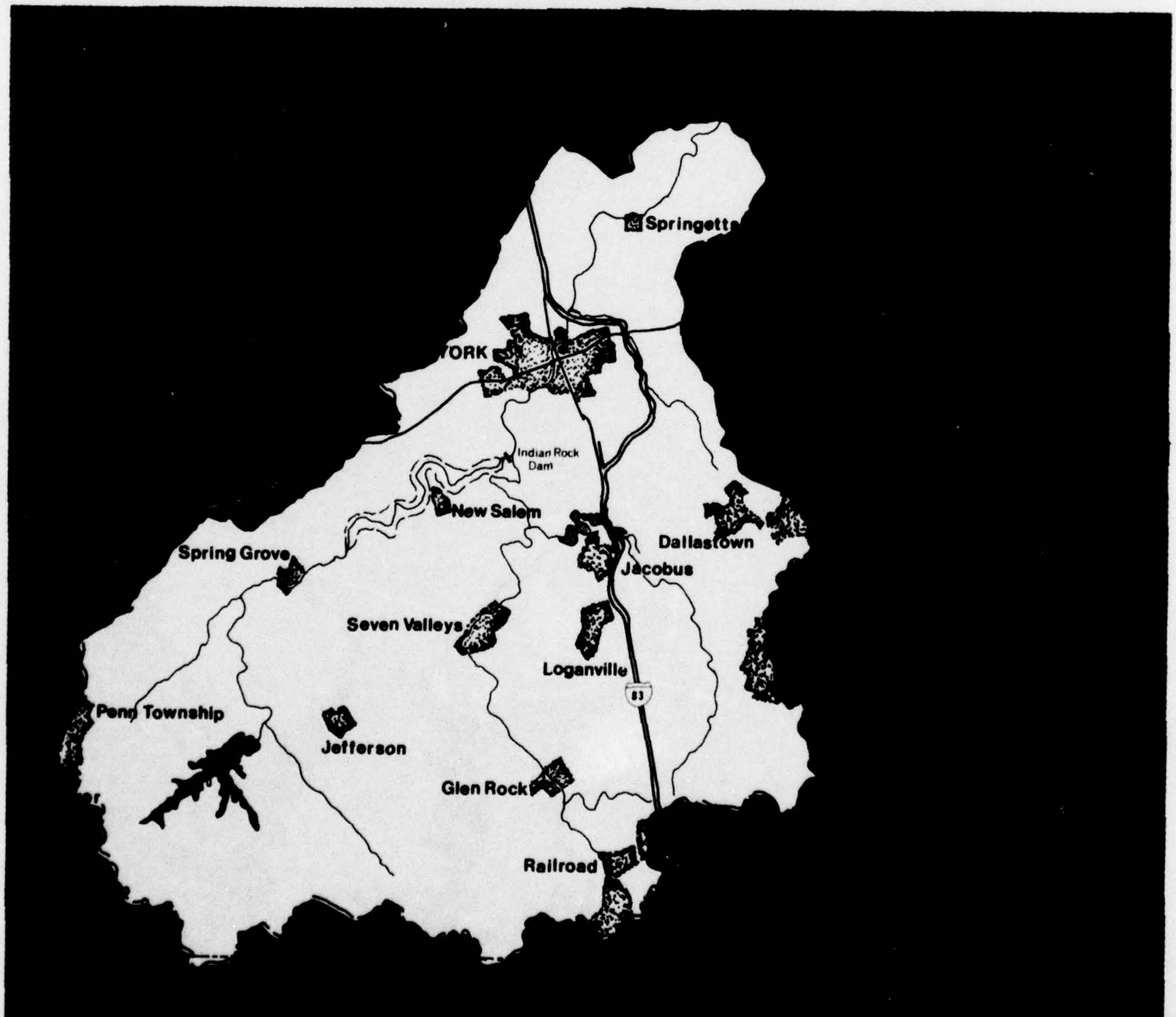


Figure 10. Codorus Creek Basin

The establishment of the boundary of the Codorus Creek Wastewater Management Study Area was a function of two limiting criteria, i.e., hydrologic characteristics and the extent of present and future urban development. Hydrologic characteristics are important predominantly from an engineering and economic viewpoint. Wastewater treatment facilities are usually located along a stream, generally on a tract of land with a rather low elevation. This allows the use of gravity pipelines, rather than pumping facilities, for transmission purposes, with a resultant substantial savings in operating cost. Consequently, an integral hydrologic unit such as a drainage basin would establish ideal boundaries for a wastewater management study. Urban development, however, normally occurs independent of hydrologic boundaries. Thus an urban center could, quite conceivably, span several hydrologic units. Good regional planning concepts dictate that the urban area be considered as an entity in studying wastewater management problems.

In applying these concepts to the Codorus Creek Wastewater Management Study, it was found that the City of York, its suburbs, and the outlying population centers of New Freedom, Shrewsbury, Dallastown, Yoe, Spring Grove, and Glen Rock are located entirely within the Codorus Creek Watershed. There are, however, urban centers which are located only partially within this watershed or lie entirely outside its boundaries, but which are closely associated with it. These include Dover, West Manchester, and Manchester Townships, and Dover Borough which are part of the Greater York Area and the outlying centers of Hanover-Penn Township, Red Lion, New Freedom, and Winterstown. The boundary of the Codorus Creek Wastewater Management Study area was established to include all of these.

Landform

The Codorus Creek Watershed is a 280 square mile basin characterized by gentle rolling hills typical of eastern farmland. Elevations vary from 243 feet above mean sea level at the Susquehanna River to 1189 feet above mean sea level at a point near Hanover, Pennsylvania. Although the land, for the most part, is moderately undulating, there are areas which contain rather sharply rising slopes. This is particularly true near the Susquehanna River where the banks of Codorus Creek, with slopes of over 25 percent, form rather steep cliffs in excess of 330 feet high. In the southern part of the basin, stream banks are somewhat less precipitous and form a variety of patterns ranging from nearly flat to sharply rising.

Transportation

Since the Codorus Creek Wastewater Management Study Area is served by a limited railroad and airline network, transportation access is primarily by highway. Access to the basin is provided in an east-west direction by U. S. Route 30 and in a north-south direction by Interstate Route 83. Route 30 is an old and historic corridor dating back to the colonial era. It provides the major link between inland communities such as Gettysburg, York, and Lancaster and the east coast at Philadelphia. Interstate Route 83 is part of a larger corridor linking the Susquehanna Valley to Baltimore. York, being at the crossroads of these two highways, occupies a strategic and readily accessible location.

Geology

One of the basic goals of the Codorus Creek Wastewater Management Study is a thorough investigation of all wastewater treatment technologies. In this regard, the geology of the study area is of particular significance — not only from the viewpoint of construction problems which unusual formations may impose, but from the viewpoint of the compatibility of various formations with land application techniques of wastewater treatment.

The Codorus Creek Basin lies within four physiographic subdivisions of the Piedmont Plateau Geologic Province, i.e., the Hanover-York Valley, the Hellam Hills, the Gettysburg Plain, and the Southeastern Upland Subdivision.

As can be seen on Figure 11, the western portion of the Codorus Creek Basin lies in the Hanover-York Valley geological unit. This subdivision consists predominantly of folded sedimentary rocks of Cambrian and Ordovician Age. The underlying bedrock is largely carbonate (limestone and dolomite) of varying purity. Associated with the carbonates are minor quantities of shales and sandstone. Slopes are nearly level to undulating, except in an area near Nashville where shale hills rise up to 500 feet above the adjacent carbonate lowlands. The carbonates are soluble and weather comparatively rapidly by solutioning. The soils produced by weathering range widely and erratically in thickness and tend to reflect in composition the lithologic characteristics of the present material. The more impure carbonate units give rise to more silty and sandy loam soils while the purer units produce soils higher in clay content. The presence of sinkholes attest to the existence of well developed internal drainage along solution enlarged joints and crevices. Groundwater underflow is rapid along permeable channels within the rock units but the distribution, orientation, and hydraulic interconnection of the complex channel ways are difficult to determine in a specific manner.

East of York, the sedimentary rock lowland extends as a narrow valley to Wrightsville. At York, however, Codorus Creek turns northward to flow in a narrow, deeply incised valley through the Hellam Hills section south of New Holland.

The extreme northern part of the basin is located in the Hellam Hills and Gettysburg subdivision. The Hellam Hills physiographic unit is an area of high knolls and elongated ridges formed on bedrock of highly resistant quartzite. Land slopes are long and steep to moderately steep with narrow ridge crests with widths of up to 100 yards. The underlying quartzite bedrock is dense and resistant to weathering and erosion. Associated soils range from silt to sandy loam in texture and from shallow (0 to 20 inches) to deep (greater than 44 inches) in depth. Generally, the thicker soil is associated with the lower land slopes (less than 8 percent) and the steeper slopes (in excess of 15 percent) are more likely to contain thinner, more severely eroded soils.

The Gettysburg Plain forms an extensive physiographic subdivision of the Piedmont Province on the northwest flank of the Codorus Creek Basin. Within this physiographic area the land surface is dissected into low ridges and hillocks forming an undulating to rolling low upland. The surface is formed on relatively soft and easily eroded red shales and sandstones of Triassic age. The soils developed on these materials range from shallow to deep and are almost always severely eroded where land slopes exceed about 8 percent. The soils range in composition from sandy loam to clay loam reflecting the sandstone or shales composition of the bedrock. Permeability characteristics also vary according to the rock type, being low to very low in the shale units and low to moderate in the sandstone units depending on degree of fracturing and relative cleanliness of the sandstone. Generally, the permeability of the Triassic shale and sandstone terrain can be expected to be intermediate between the dense quartzite and other metamorphic rocks and the solution affected carbonate rocks.

The bulk of the land area within the Codorus Creek Basin, that lying generally southeast of Codorus Creek and the West Branch of Codorus Creek from York to Hanover, is within the Southeastern Upland physiographic subdivision. The land surface in this physiographic area is characterized by a steep sloped to rolling topography with well defined relatively narrow ridge tops. The bedrock of the area consists of interbedded quartzites and phyllite in a broad band adjacent to Codorus Creek and the West Branch and Wissahickon schist in the headwaters region of the southern tributaries.

Soils developed on these metamorphized rocks range in texture from silt to sandy loams with a generally good drainability and in thickness from shallow to deep. Over broad expanses of the region, generally deep soils averaging 5 feet or more in thickness

and with relatively high permeability, estimated to be in the order of 10 to 100 gallons per day per square foot, are likely.

The bedrock underlying the Southeastern Upland Subdivision is generally tight with permeability resulting only from the shallow network of joints and fractures that produce narrow lineal openings in the rock. These are often adequate to provide small water yields to wells, sufficient for domestic and farm needs. Locally, weathering of the Wissahickon schist is reported to extend to depths in excess of 80 to 90 feet. The unconsolidated material is sandy in texture and capable of somewhat larger (limits unknown) water yields.

Climate

The general climate of the Codorus Creek Basin is relatively mild and is tempered by the proximity of the Atlantic Ocean. Three general types of weather patterns influence the area: cold air flowing down from the Arctic; warm, moist air from the Gulf states; and cool moist air from the ocean.

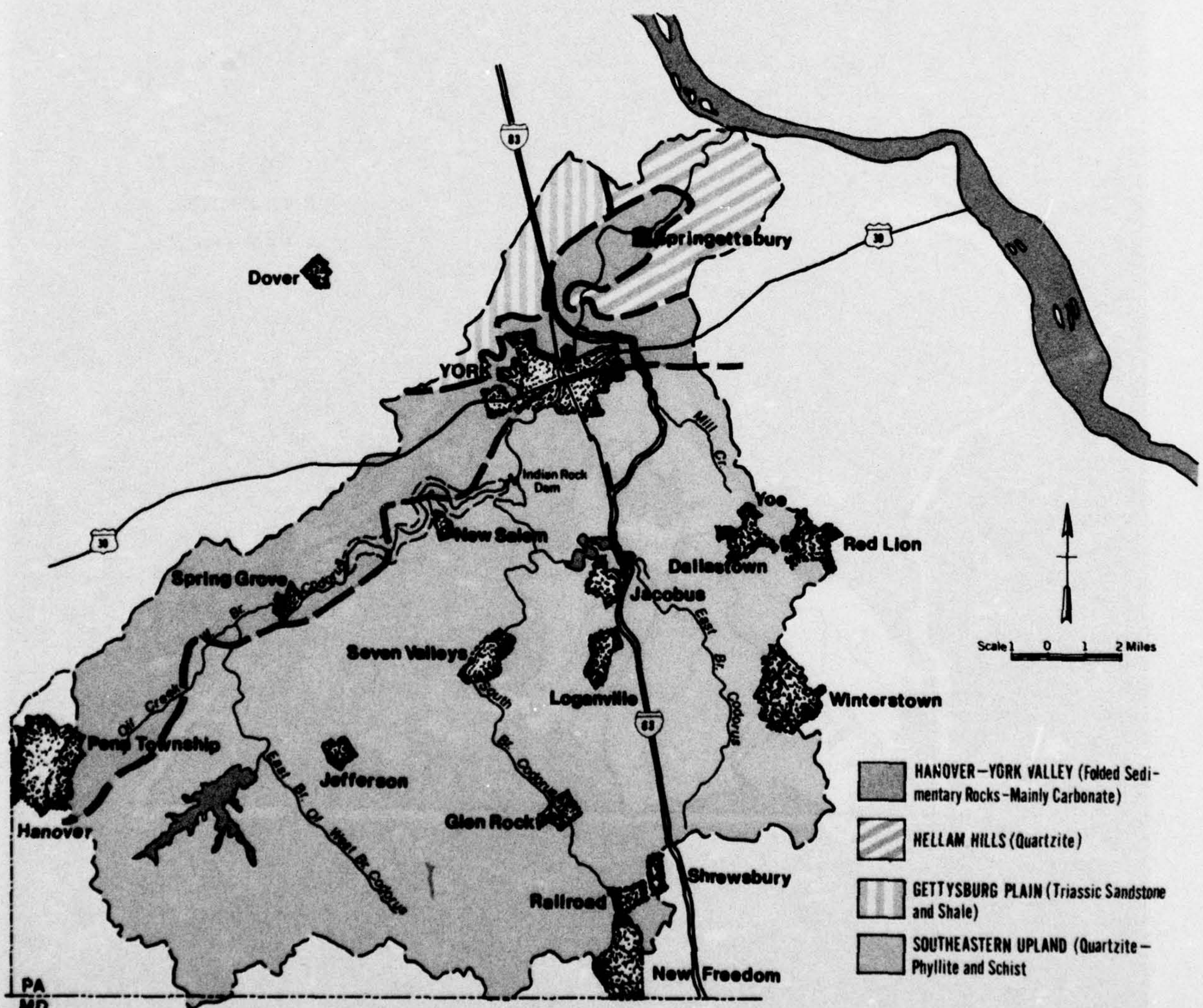


Figure 11. Study Area Geology

The precipitation in the basin is rather uniform throughout the year, averaging about 42 inches annually. Precipitation in the form of snow averages 24 inches per year. Brief windstorms with gale force frequently occur in the fall, winter and early spring. Major storms, such as hurricanes, occasionally strike the region in the late summer and early fall. Tornadoes are not common and have caused only limited damage.

Temperatures in the area are generally moderate, averaging approximately 53 degrees on an annual basis. Seasonal variations are not extreme with the winter average being 33 degrees and the summer 78 degrees.

Hydrology

Codorus Creek, the focus of this wastewater management study, consists of four major hydrologic elements – the West Branch

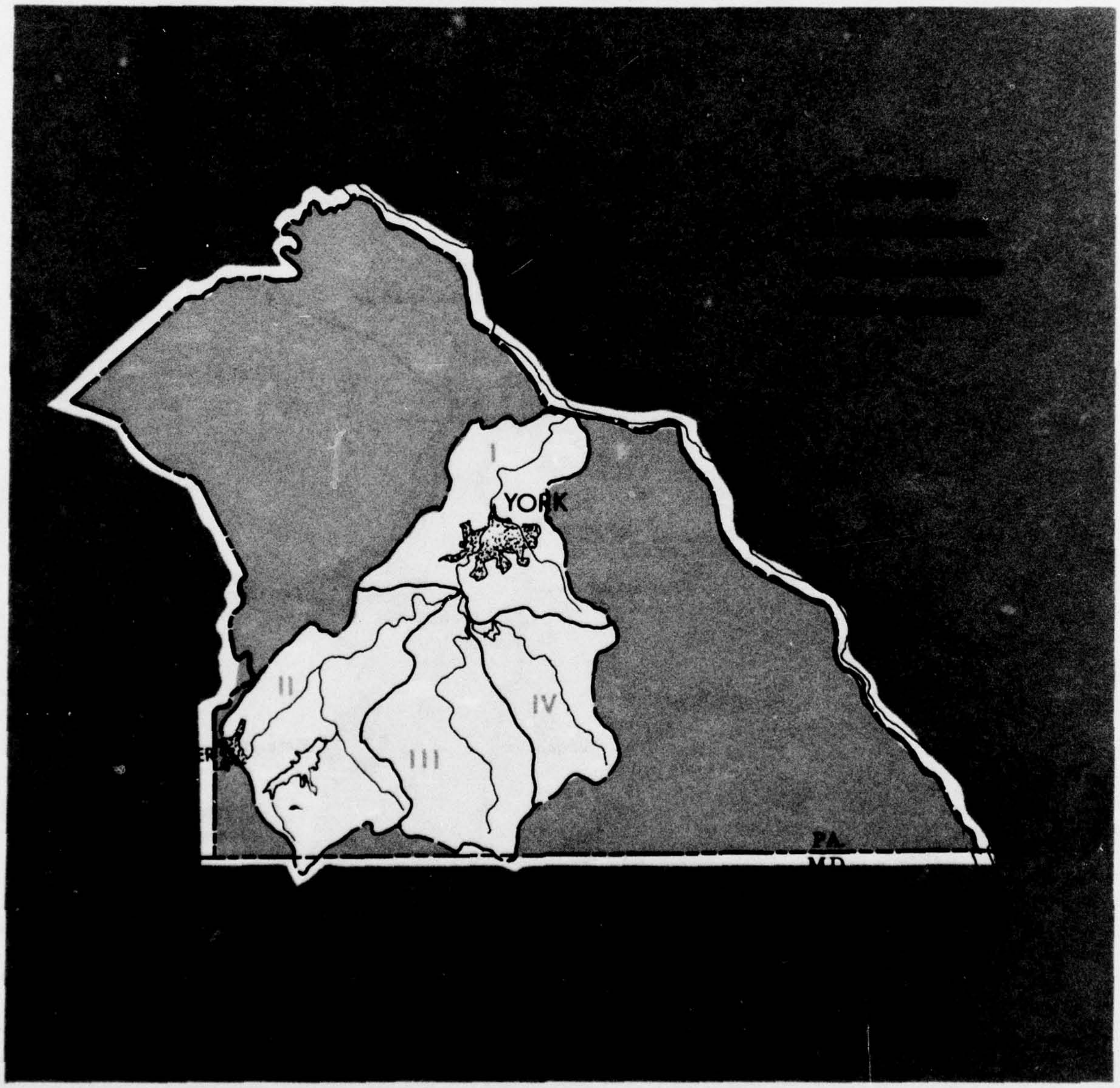


Figure 12. Hydrologic Sub-Divisions

which originates near Hanover, the South Branch which originates near Railroad-New Freedom and the East Branch which originates near the intersection of Interstate Route 83 with the Maryland state line. These three streams flow in a northerly direction to a point immediately south of York where they join to form the main stem. This in turn flows in a northeasterly direction, through the City of York to a junction with the Susquehanna River below the York Haven Reservoir. The location of these branches of Codorus Creek and the drainage areas served by them are shown on Figure 12.

The watershed area of Codorus Creek, at its confluence with the Susquehanna, is 280 square miles. The West Branch drains an area of approximately 94 square miles, while the South and East Branches receive runoff from areas of approximately 72 and 45 square miles respectively. The average annual runoff for the entire basin is approximately 279 cubic feet per second (cfs). Of this, approximately 50 cfs is presently used or controlled for municipal and industrial water supply. The highest flow recorded in the basin was 32,000 cfs at York during the 1933 flood. The minimum monthly flow recorded at the mouth of Codorus Creek is 128 cfs.

Water resources development of Codorus Creek is rather limited as evidenced by the fact that there are only four reservoirs and one local flood protection located within the basin, i.e., the City of York Local Flood Protection Project, Indian Rock Dam, Lake Marburg, Lake Williams, and Lake Redman. The Indian Rock Dam is a single purpose flood control project constructed by the Corps of Engineers. At the present time, there is no permanent lake impounded behind this structure, although studies have shown that this is hydrologically and structurally possible.

Lake Marburg is the focus for the Codorus Creek State Park. In addition to providing a pleasant recreation resource, this reservoir was developed for the express purpose of furnishing process water to the P. H. Glatfelter Paper Mill. Both Lake Williams and Lake Redman are water supply reservoirs for the City of York. Additional potential for reservoir development in Codorus Creek is limited.

Population

The inhabitants of an area – their numbers, their distribution, and their social and economic characteristics – weigh heavily in determining the magnitude of a wastewater management system. The numbers of people and their social and economic characteristics are important in determining the quantities of wastewater to be expected and the distribution of population in determining system configuration and size. As shown on Table 2, the 1970 population of the Codorus Creek Wastewater Management Study Service Area is 193,177 persons. This is expected to increase to 240,430 persons by the year 1980, to 332,886 persons by the year 2000, and 447,150 persons by the year 2020.

TABLE 2

STUDY AREA POPULATION

Population Centers	1970	1980	2000	2020
Greater York	117,681	115,118	227,032	300,000
Hanover-Penn Township	28,777	32,500	40,400	50,000
Shrewsbury-New Freedom-Railroad	3,519	6,503	6,989	20,000
Glen Rock	1,600	2,136	2,925	7,500
Spring Grove	1,669	3,065	3,368	7,500
Red Lion-Dallastown-Yoe	9,995	15,542	20,419	30,000
Jefferson Borough	540	511	545	575
Seven Valleys Borough	688	743	886	900
Loganville Borough	931	1,207	2,092	2,400
Jacobs Borough	1,360	2,023	3,036	3,700
New Salem Borough	384	1,486	1,653	1,625
Winterstown Borough	425	400	399	400
Rural areas	25,830	19,196	23,122	22,550
TOTAL	193,177	240,430	332,866	447,150

Population densities within the study area vary from that of typical eastern rural farmland to that of highly urbanized areas. By far, the majority of the people reside in the York Metropolitan Area. This population center contains approximately 118,000 per-

sons or 63 percent of the total. The Hanover-Penn Township population of approximately 29,000 is the second largest while the remaining population centers contain less than 10,000 persons in total. The six semi-urban communities together comprise only a minor portion of the population, totaling about 4,400 persons.

As in most areas of the country, the past decade has brought considerable change in development patterns; namely, a declining population within the central City of York and expanding suburban population around the central city in such urban areas as Springettsbury, Dover, and Manchester Townships. The remainder of the communities in the study area are stable with few exceptions, such as Hanover-Penn Township which in itself is expanding and Red Lion-Dallastown-Yoe which is becoming part of the expanding Greater York Area.

Future population trends are not expected to differ greatly from those of the last 10 years. The York Metropolitan Area will continue to grow at a greater rate than the more rural communities. Development trends are such that major growth will radiate out from the York urban core, east along U.S. 30 toward Hallam Borough, north along Interstate Route 83, and northwest to Dover. Of the outlying communities, those expected to have the largest growth are Jacobus, Loganville, and New Salem Boroughs. Total rural population is not expected to change significantly in the next 50 years.

Although geographically the study area is relatively small, cultures are extremely diverse ranging from that of a typical Pennsylvania Dutch farmer to that of an urban dweller. Even with this variety of background, many common attitudes prevail throughout the area. A high degree of mobility has allowed almost all residents to be exposed to various cultures, so that progressively fewer have purely parochial outlooks. On the other hand, greater population densities have brought increasing social problems to the foreground – problems which are compounded by the degraded quality of the waters of Codorus Creek.

Economic Activity

Like population, economic activity is very influential in the quantities of wastewater to be expected. This is true not only in terms of the amount of wastes which may be generated in industrial processes, but in the nature of these wastes and the influence that employment in these industries has on the standard of living prevalent in the community.

Economic activities in the Codorus Creek Wastewater Management Study Area generally consist of manufacturing, retail-services, agriculture, mining, and tourism. In terms of employment and volumes, manufacturing and retail sales dominate the local scene with manufacturing accounting for approximately 47 percent of the total labor force and retail-services 51 percent. Most of the manufacturing activities are located in the Greater York area. Significant manufactured products include non-electrical machinery and apparel goods, although a variety of products are represented.

The retail-services industry consists of those activities related to retail trade, wholesale trade and general service industries. While there has been a decline in retail trade in the City of York, this decline has been offset by a rapid growth in the suburban area. Overall, this group of activities is the fastest growing economic sector in the study area and presently employs approximately one-half of the total labor force.

Although much of the land in the Codorus Creek Basin is devoted to agriculture, its contribution to employment is rather small. Less than two percent of the employment in the study area is devoted to this activity.

York County is tourist country. Many tourists are attracted here because of its colonial heritage, its scenery, its Amish culture, and its role in the Civil War. Although this is a most important economic activity, its total contribution to employment is rather low.

It is anticipated that manufacturing and retail-services will continue to offer the

major employment opportunities in the study area. Manufacturing, although decreasing in terms of proportion of employment, will actually increase in terms of job opportunities. The retail-service industries sector is growing at a rapid rate, both for the study area and the entire county. On the other hand, agriculture and mining activities are expected to remain stable. It is concluded that the economy of the Codorus Creek Wastewater Management Study Area will be fully diversified within the next 50 years.

Existing Wastewater Management Facilities

The existing and presently programmed municipal wastewater management systems are shown on Figure 13. As can be seen, the extent of municipal service in the study area is limited to York City, Springettsbury Borough, Dover Borough, Penn Township, Hanover, Red Lion, Glen Rock, and Spring Grove. These facilities serve approximately 59 percent of the people residing in the study area. The remaining people are disposing of their wastes through private systems, in many cases septic tanks.

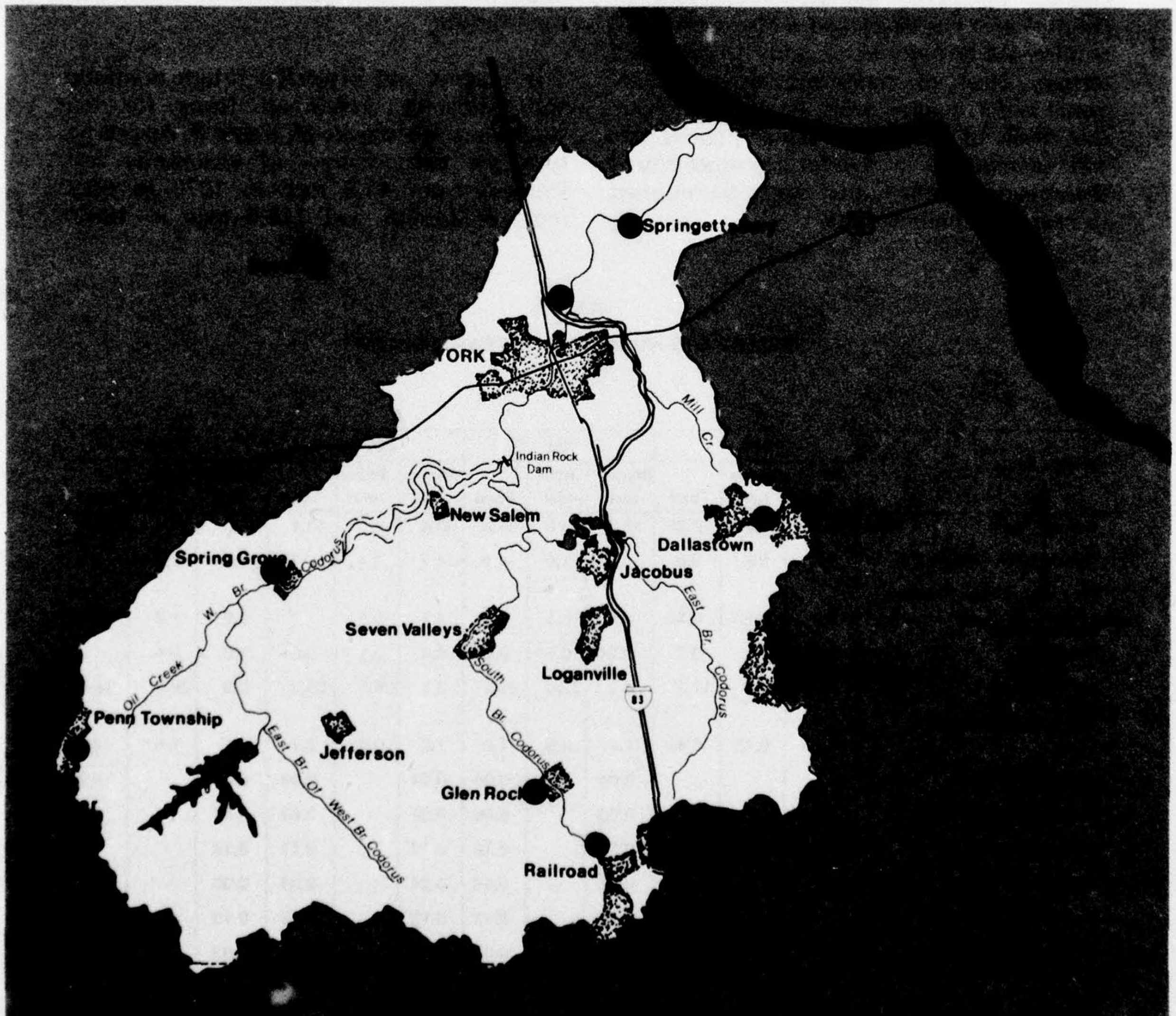


Figure 13. Existing Wastewater Treatment Facilities

The total municipal wastewater flow for the Codorus Creek Wastewater Management Study Area is approximately 41.0 million gallons per day (mgd). Of this, 71 percent or 29.2 mgd is generated by industries. Twenty-five of these industries discharge wastes directly to the stream. Twenty-four contribute a combined total of 2.7 mgd, while P. H. Glatfelter Company generates 17 million gallons of wastes daily.

For the most part, existing municipal treatment facilities are achieving, through biological systems, treatment equivalent to secondary level. In order to institute its water quality standards, the Commonwealth of Pennsylvania has developed a plan which will require nearly every community to provide a tertiary level of treatment. Emerging national water quality goals, however, indicate that levels of treatment over and above this will be required in the future, especially if the streams of our nation are to be returned to near their natural state.

Wastewater Flow Projections

Wastewater falls into four general classes — domestic sewage, industrial wastes, urban runoff, and agricultural runoff. (See Chapter IV for a detailed description of the characteristics of these wastes.) The quantities of domestic and industrial waste are primarily a function of man's activities, while urban and agricultural runoff are a result of precipitation in the form of either rain or snow. Because quantities of urban and rural runoff are natural phenomena, brief summaries are difficult to construct. Consequently, reference is made to Appendix A, Volume IV for estimations of the quantities of urban and rural runoff.

The present and projected future domestic and industrial wastewater flows for the study area are shown on Table 3. As can be seen the total amount of wastewater will increase from 41.0 mgd in 1970 to 60.3 mgd, 88.3 mgd, and 116.6 mgd in 1980,

TABLE 3
PRESENT AND PROJECTED WASTEWATER FLOW
(MGD)

Service Area	1970			1980			2000			2020		
	Municipal	Industrial	Total	Municipal	Industrial	Total	Municipal	Industrial	Total	Municipal	Industrial	Total
Greater York	9.12	10.73	19.85	16.5	13.3	29.8	30.4	17.7	48.1	45.0	23.4	68.4
Hanover-Penn Township	2.2	0.8	3.0	3.1	1.0	4.1	4.7	1.4	6.1	6.8	2.1	8.9
Shrewsbury-New Freedom-Railroad	0.	0.25	0.25	0.5	0.4	0.9	1.1	0.8	1.9	2.2	1.4	3.6
Glen Rock	0.2	-	0.2	0.24	0.04	0.24	0.4	0.1	0.5	1.0	0.4	1.4
Spring Grove	0.1	17.2	17.3	0.2	23.0	23.2	0.3	28.0	28.3	0.8	28.0	28.8
Red Lion-Dallastown-Yoe	0.25	0.18	0.43	1.0	0.6	1.6	1.8	0.9	2.7	3.2	1.5	4.7
Jefferson Borough	-	-	-	0.04	-	0.04	0.04	-	0.04	0.05	-	0.05
Seven Valleys Borough	-	-	-	0.06	-	0.06	0.07	-	0.07	0.07	-	0.07
Loganville Borough	-	-	-	0.10	-	0.10	0.17	-	0.17	0.19	-	0.19
Jacobus Borough	-	-	-	0.16	-	0.16	0.24	-	0.24	0.30	-	0.30
New Salem Borough	-	-	-	0.12	-	0.12	0.13	-	0.13	0.13	-	0.13
Winterstown Borough	-	-	-	0.03	-	0.03	0.03	-	0.03	0.03	-	0.03
TOTAL	11.9	29.2	41.0	22.0	38.3	60.3	39.4	48.9	88.3	59.8	56.8	116.6

2000, and 2020, respectively. As far as domestic wastes are concerned, these increases are due to population increases, increases in per capita water use, and expansion of wastewater systems.

Projected future wastewater service areas are shown on Figure 14. The larger service areas are York-Dover-Springettsbury-Dallastown-Red Lion-Yoe Township; Spring Grove; Shrewsbury-New Freedom-Railroad; Hanover-Penn Township. Flow projections are based on the assumption that 90 percent of the service area population will be serviced by 1980 and 100 percent by the year 2000.

In addition, it is assumed that per capita contributions will increase at the rate of 8 gallons per person every 10 years.

Industrial and commercial wastewater flow projections are based on the realization that there are not only variations in the quantities of wastes generated by different industries, but that all industries will not experience the same growth. For instance, a major impact on flow projections is the expected shift from a predominately manufacturing economy where each employee is expected to generate 292 gallons per capita per day

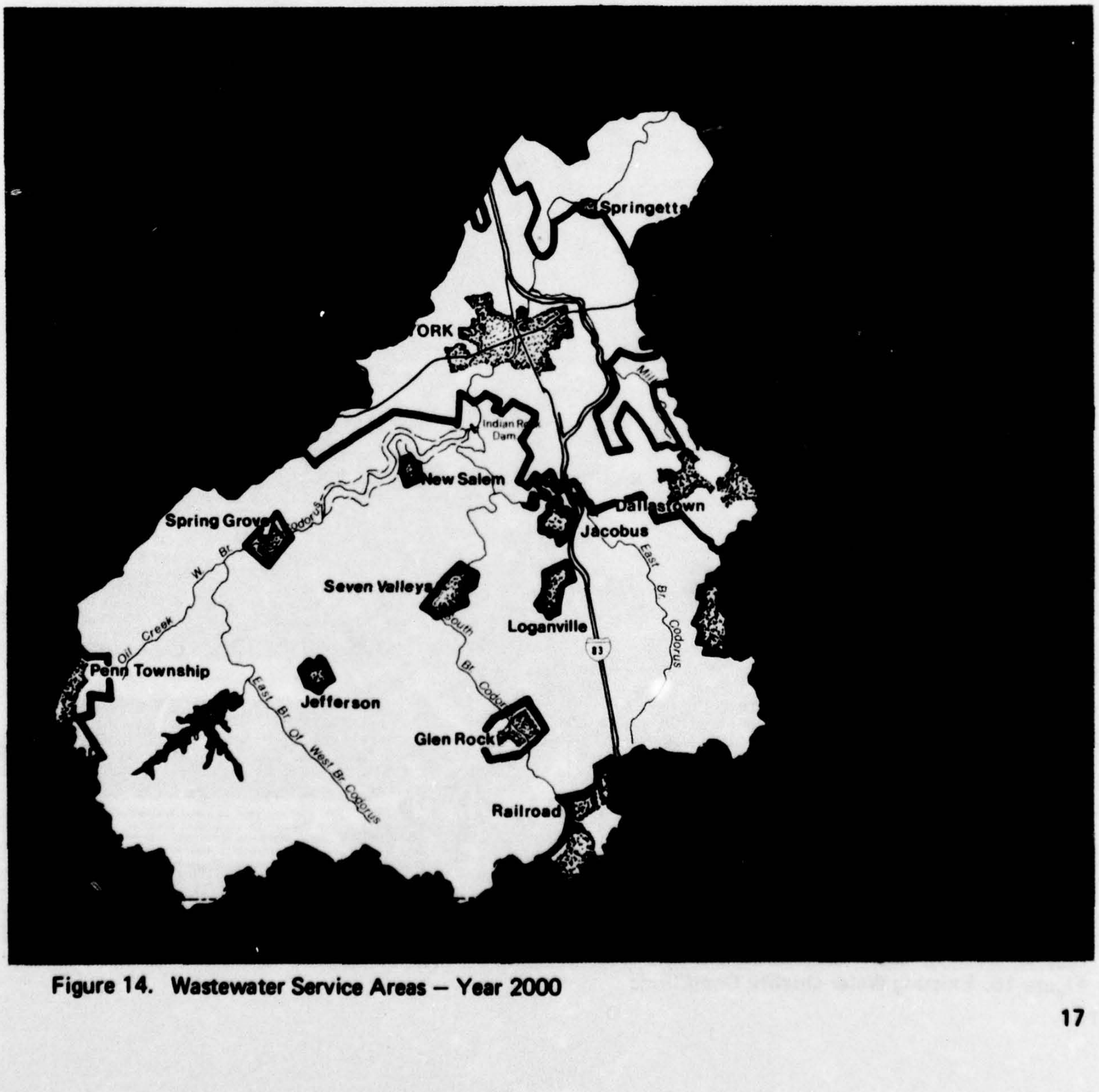


Figure 14. Wastewater Service Areas – Year 2000

(gpcpd) to one of service where only 122 gpcpd can be expected.

It is difficult to estimate the level of output of each industry over the next 50 years and the problem is compounded by the many process modifications available. Therefore, it has been assumed that industrial wastewater flows will be proportional to employment in a specific industry. This balances two factors — output per employee will probably increase, while wastewater discharge per unit of output will probably decrease.

THE PROBLEMS

As discussed in Chapter IV, the origins of water pollution fall into four general classes: municipal sewage, industrial wastes, urban runoff and agricultural runoff. Contained in all four of these are foreign materials — pollutants which can render a stream useless for any purpose but to act as an open sewer. The list is long, but pollutants of particular concern are: oxygen demanding wastes which rob a stream of the dissolved oxygen so vital to aquatic life; plant nutrients like phosphorus and nitrogen which can over-

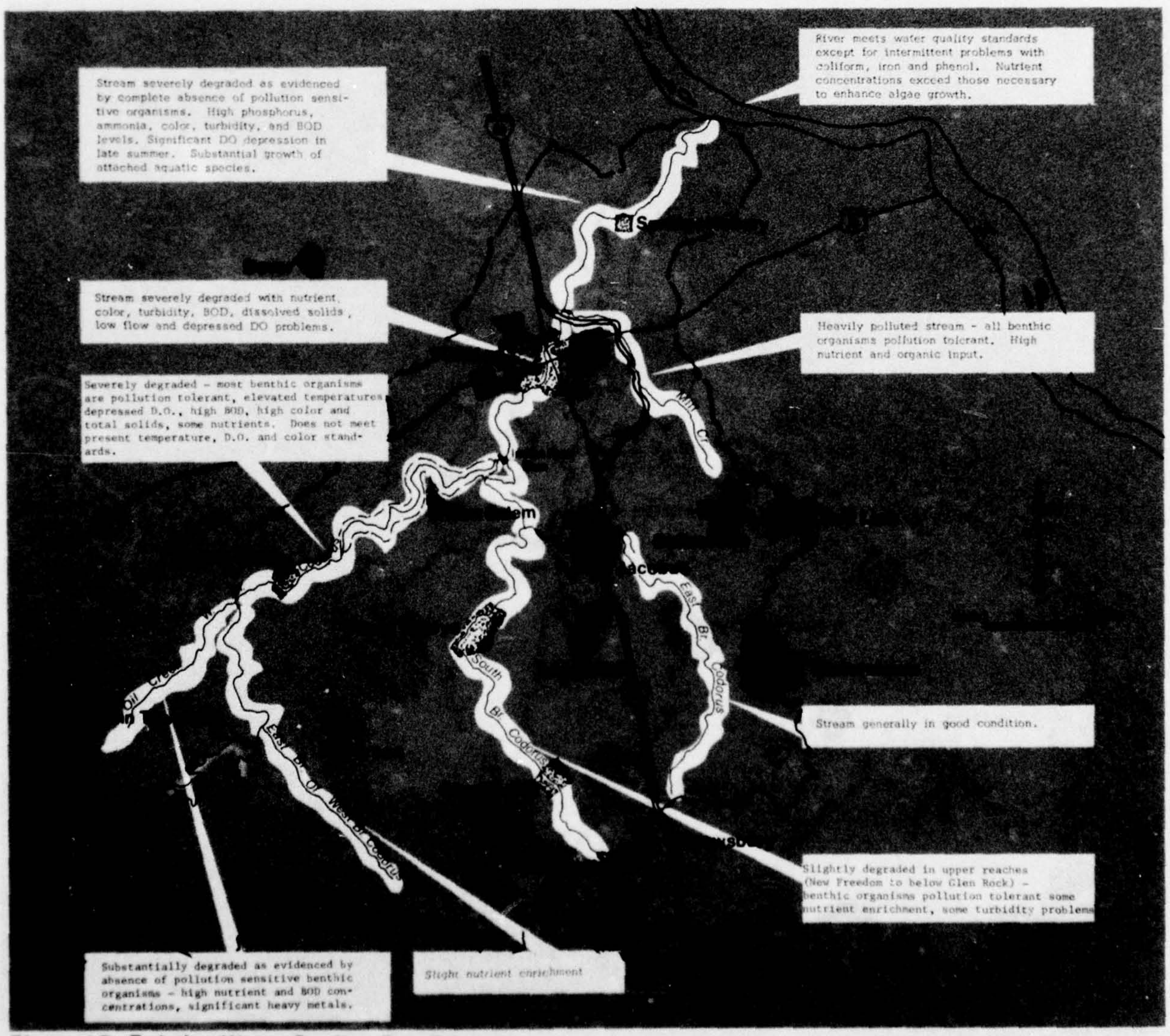


Figure 15. Existing Water Quality Conditions

stimulate plant growth, thereby literally choking a stream with odor causing decayed matter; solids, both suspended and dissolved, which can smother life in a stream; and pathogenic agents which, when ingested by man, can cause serious illness. All of these pollutants and many more are present in Codorus Creek in quantities which are cause for concern. This has been proven time and again by water quality surveys, particularly those conducted by the Pennsylvania Department of Health in the period from 1968 to 1970 and those conducted by the Environmental Protection Agency in 1971.

The results of the survey conducted by the Department of Health are shown on Table 4, and they speak for themselves. But the impact becomes even more profound when the information is portrayed graphically, such as on Figures 15 and 16. Degradation, although just now emerging in the southerly portions of the basin, is markedly evident in other areas. In fact, as much as 75 percent of the flow in the main stem of Codorus Creek is often wastewater. It is clear that the quality of the waters of Codorus Creek is extremely degraded.

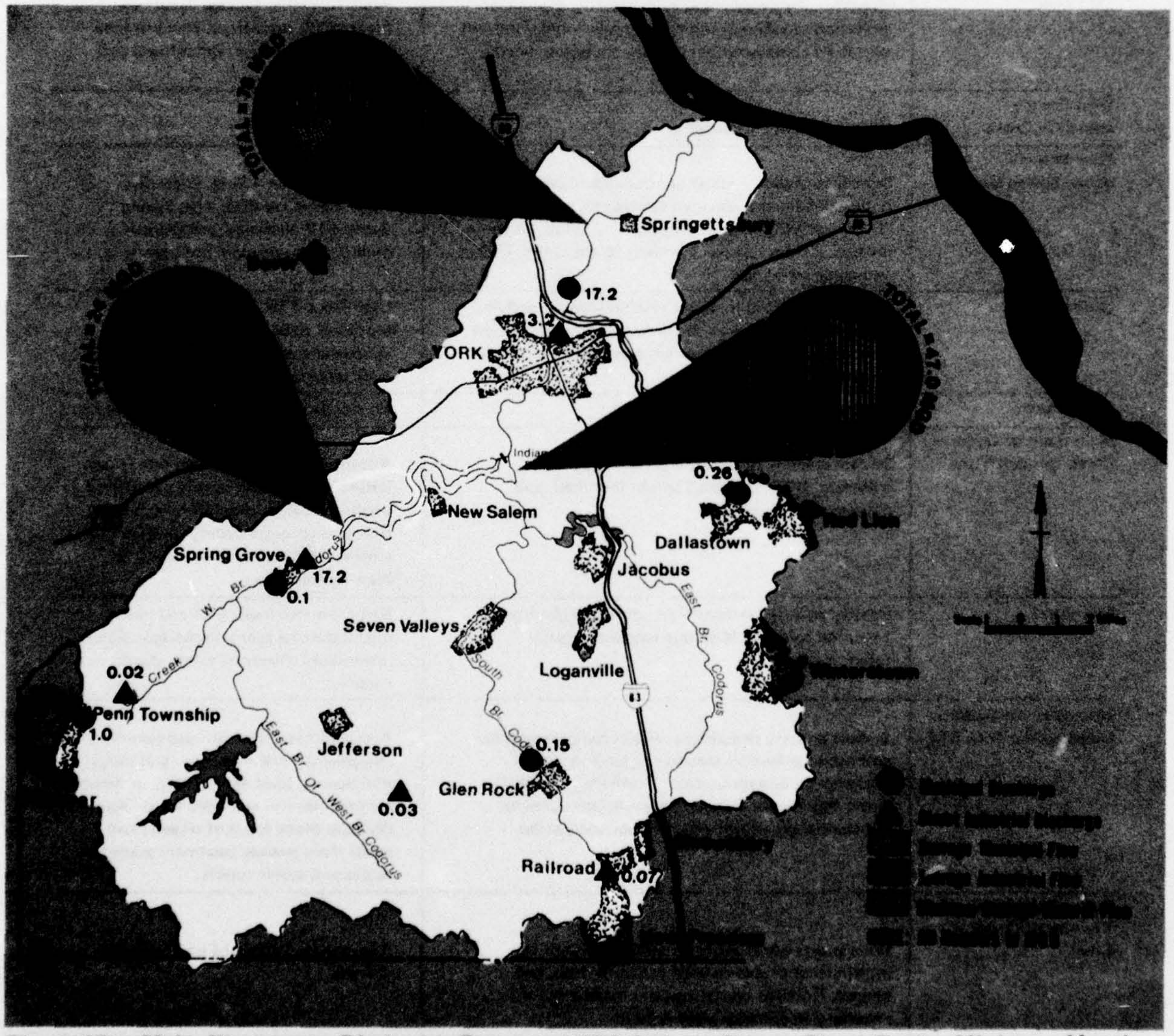


Figure 16. Major Wastewater Discharges Compared With Natural Stream Flows During Minimum Month

What has caused Codorus Creek to reach this state is a nebulous issue. More important are the water quality/environmental relationships which must be addressed to improve it. In other words, what factors are presently contributing to the degraded condition of Codorus Creek? Certainly, a major contributor is inadequate treatment of municipal and industrial wastewater with the resultant oxygen deficiencies in the stream, visual degradation of the creek, and nutrient enrichment of both Cooorus Creek and the Susquehanna River. Not so obvious, however, are the reductions in natural stream flows and increases in wastewater flows brought about by population and economic growth. Also not so obvious is the present trend toward the construction of a profusion of treatment plants in remote areas where natural stream flows are a minimum and

TABLE 4

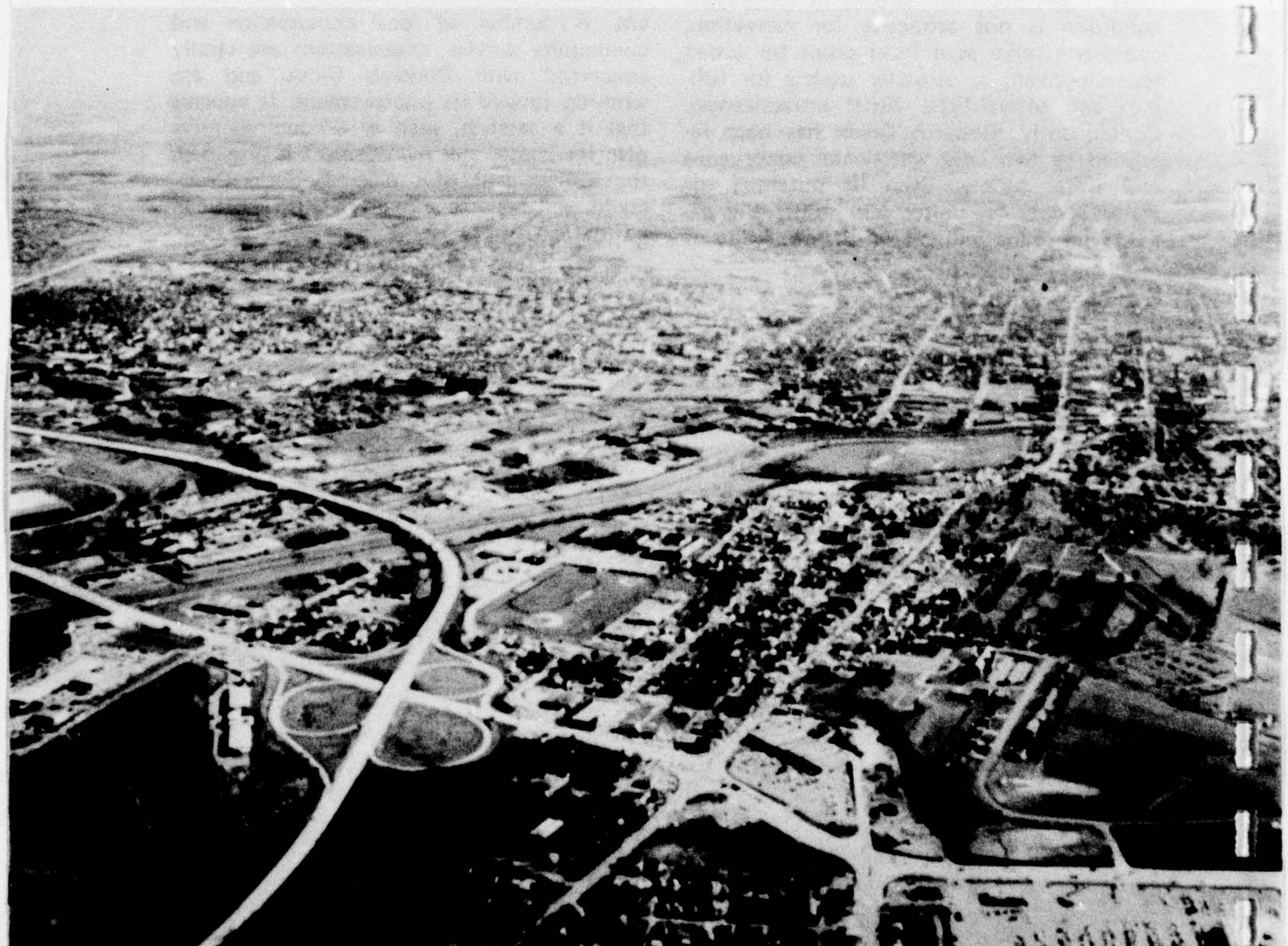
SUMMARY OF WATER QUALITY CONDITIONS

Tributary	General Conditions	Causative Factors
Oil Creek	Substantially degraded as evidenced by absence of pollution sensitive benthic organisms – high nutrient and BOD concentrations, significant heavy metals.	Penn Township Sewage Treatment Plant (STP) discharges, Hanover area industrial discharge, agricultural and sediment runoff.
West Branch above Oil Creek	Slight nutrient enrichment.	Land runoff.
West Branch below Spring Grove	Severly degraded – most benthic organisms are pollution tolerant, elevated temperatures, depressed D. O. high BOD, high color and total solids, some nutrients. Does not meet present temperature, D.O., and color standards.	Primary source – P. H. Glatfelter Paper Company discharge, Spring Grove STP discharge, some accumulation of upstream pollutants.
South Branch	Slightly, degraded in upper reaches (New Freedom to below Glen Rock) – benthic organisms pollution tolerant, some nutrient enrichment, some turbidity problems.	Glen Rock STP., laundromat and septics at Railroad/New Freedom, agricultural and sediment runoff, poor stream-bed management.
East Branch	Stream generally in good condition.	No significant concentrated discharges.
Main Stem of Codorus Creek through York	Stream severely degraded with nutrient, color, trubidity, BOD, dissolved solids, low flow, and depressed DO problems.	Accumulation of upstream municipal, industrial, and land runoff pollutional discharges. Reduced natural dilution flow due to water supply diversion upstream. Degradation due largely to West Branch flows.
Mill Creek	Heavily polluted stream – all benthic organisms pollution tolerant. High nutrient and organic input.	Red Lion municipal STP and individual industrial plant discharges. Significant likely effects of urban storm runoff.
Main Stem of Codorus Creek below York STP	Stream severely degraded as evidenced by complete absence of pollution sensitive organisms. High phosphorus, ammonia, color, turbidity, and BOD levels. Significant DO depression in late summer. Substantial growth of attached aquatic species.	Accumulated effect of upstream discharge and York municipal and industrial wastes. Low natural flow in summer summer months available for dilution. Periodic shock loads of organic and solids from sewage treatment plant bypasses and storm runoff.
Susquehanna River in Vicinity of Codorus Creek	River meets water quality standards except for intermittent problems with coliform, iron, and phenol. Nutrient concentrations exceed those necessary to enhance algae growth.	Accumulated effect of upstream discharges.

have limited capacity for assimilation of wastes. This is of particular concern in the upper reaches of the basin.

The local people, however, do not perceive the problem in this context. They associate it with the uses that can be made of the stream. They question how a stream which smells, is discolored, has insufficient flows, and is a potential health hazard can be used for any meaningful purpose. Their dilemma is manifested in the name they have given the stream — "The Inky-Stinky Codorus." They know that the stream in its present condition is not attractive for recreation, could not serve as a focal point for urban redevelopment, is virtually useless for fishing, and offers little visual attractiveness. Consequently, Codorus Creek has been relegated to two uses; wastewater conveyance and water supply. Even its potential for water supply is limited. By 1985, the demand for water will exceed the capability of the creek to furnish it. If nothing is done, Codorus Creek will have failed even in this role.

But the water quality problems of Codorus Creek can be solved. The creek can once again be restored to near its natural state and can once again be a focus of man's activities. It can become a center for recreation. It can become a focus for urban development and restoration. But, this will only come about through concerted effort and dedication on the part of the local people and evidence of this is already present. A number of local conservation and community service organizations are vitally concerned with Codorus Creek and are working toward its improvement. It appears that if a catalyst, such as a comprehensive plan for wastewater management is provided, the achievement of a clean Codorus Creek could well become a reality. This report can be that catalyst.



CHAPTER IV THE TECHNOLOGY OF WATER POLLUTION CONTROL*

POLLUTANTS

The environment we live in is like a house. When the house is tidy, it functions smoothly and the people inside can live easy, unrestricted lives. When the house is poorly managed and becomes disorderly, however, its inhabitants are uncomfortable and their life style is constrained and tense.

In that analogy the clutter in the environmental house is pollution. Pollutants are simply substances which do not belong where they are now. Individually they need not necessarily be harmful, but in great quantities or in combination they upset the workings of the natural biochemical processes which "houseclean" the Earth and make survival for the human species possible. Pollutants come in many forms: organic, bacterial, inorganic, dissolved, colored, etc. Uncontrolled, they can contaminate the land, the air or the water and make them unfit for the constructive uses to which men and other creatures might put them.

The origin of pollutants which attack the quality of ground and surface waters fall into four broad classes:

Domestic Sewage

Industrial Wastes

Urban Runoff

Agricultural Runoff

Domestic sewage is water which has been used for ordinary household purposes like laundering and bathing or to carry away human wastes. In most urban areas it flows from home plumbing systems into subsurface collection lines which carry it to treatment plants or, all too often, directly into the nearest natural body of water. It is heavily organic, though the introduction of synthetic detergents has given domestic sewage some of the characteristics of industrial waste.

Water-borne pollutants also emanate from industry as by-products of manufacturing processes. Typically, they can be organic wastes from food processing or inorganic waste supplied by mineral substances as varied as the fabrication techniques which produce them.

Even the water which falls as rain can be a pollutant. It becomes dirty as it washes over the land, possible picking up fertilizers and pesticides which may have been utilized on the land by farmers. This is agricultural runoff. Limited technology exists for controlling it.

The rainwater can also become polluted as it washes off buildings and streets in populated areas forming urban runoff. Many cities do not have separate collection systems for this urban runoff of stormwater but combine it directly with the sewage flowing in municipal sewer systems.

Collectively, such polluted domestic, industrial, urban, and agricultural flows are called wastewater. To prevent environmental damage, wastewater should be treated to remove pollutants or at least render them harmless before they are discharged into receiving waters. In a river system, it is the nature and quantity of the pollutants which determines the dimensions of a water pollution problem and the techniques best applied to abate it.

In the Codorus Basin wastewaters contain four general types of pollutants: 1) oxygen-demanding wastes; 2) nutrients; 3) solids; and 4) pathogenic agents.

Oxygen-Demanding Wastes

Organic materials are found in domestic sewage and industrial wastes of plant and animal origin. In this basin manufacturing

*The majority of this chapter is derived and/or reproduced from *The Merrimack: Designs for a Clean River*, a feasibility study prepared by the North Atlantic Division, U.S. Army Corps of Engineers, September 1971, pp. 29-46.

processes like paper production are particularly heavy contributors of organic contaminants. These wastes are measured in terms of biochemical oxygen demand (BOD), or the amount of oxygen necessary for bacteria to consume organics in the natural biological cleansing process. In addition to readily biodegradable wastes, refractory organics representing an additional oxygen depletion requirement still remain. The measurement of these strengths as chemical oxygen demand (COD) is related again to oxygen consumption, this time by a laboratory chemical reaction. However, the refractory or stubborn nature of these organic chemicals precludes their rapid chemical breakdown in nature. Because fish and other aquatic organisms must compete with oxygen-demanding wastes for enough oxygen to sustain life, dissolved oxygen, BOD, and to a lesser extent COD levels are critically important to a healthy stream community.

Nutrients

Nitrogen and phosphorus are the two principal polluting nutrients. Added to wastewater through large amounts of domestic sewage, industrial wastes and runoff from fertilized land, they are excellent examples of too much of a good thing in the wrong place. They are essential to plant life, but in excess quantities, they can over-stimulate growth of algae and aquatic plants. These so-called "blooms" of algae are aesthetically unpleasant and can cause severe oxygen demand as well as taste and odor problems.

Solids

A wide variety of materials entering wastewater flowing from manufacturing processes, agricultural practices, and weathering of natural sources are referred to as solids. These solids can be "suspended" or "dissolved" depending on whether or not they can be trapped on a filter. Dissolved solids, or those which pass the filter, consist generally of inorganic minerals. If the concentration of these solids becomes too high, the water becomes unacceptable as a water supply source because of its laxative effect on humans, its residue left in industrial processes, and its toxicity to agricultural products. Solids retained on filters are "suspended" and in excessive amounts can cause degradation of water quality by coloring the water or by ruining the bottom habitat of the watercourse by prohibiting primary food production for fish.

Pathogenic Agents

In this category are the disease-producing viruses and bacteria which are introduced to surface and ground water by domestic sewage and by certain kinds of industrial processes like tanning and meat packing. Pollution levels for pathogens can be measured in terms of indicator organisms called coliform, the bacteria commonly present in the intestines of warm-blooded animals.

PROCESSES

To deal with this ever-increasing number of pollutants, technology has developed a range of individual treatment processes designed to address different components of a wastewater pollution problem. No single process can do the whole job. But together, combined into wastewater management systems, they can produce effluent of better quality than the water we drink every day. To make the explanation of treatment processes considered in the report more easily understood, the following discussion of water renovation techniques is organized into water oriented and land oriented approaches.

Water Oriented Processes

Basic Processes

For domestic sewage and many pre-conditioned industrial wastes, basic treatment begins with the primary processes. As wastewater enters the treatment plant, it flows through a screen. The screen removes gross solids and large floating objects like sticks and rags which might foul plant equipment. After screening, the wastewater passes into a grit chamber where sand, grit, and small stones are allowed to settle to the bottom. But even when screening and degritting are complete, the wastewater still contains min-

ute particles of suspended solids. This material can be removed by the sedimentation process, the major component of the primary treatment operation. Here the velocity of the wastewater is reduced and gravity works to settle suspended solids to the bottom of the sedimentation tank. The mass of solids settled out in sedimentation is called raw sludge. In terms of efficiency of pollutant removal, typical primary treatment reduces BOD by approximately 35% and suspended solids by some 65%. Constituents not significantly affected include dissolved organics, heavy metals, nutrients, and other dissolved solids.

To complete primary treatment, the effluent or liquid pumped from the sedimentation tank to outfall pipes undergoes chlorination. Chlorine gas is fed into the water to eliminate pathogenic bacteria, and after a thirty-minute retention period, the effluent is discharged into a receiving stream. By itself, primary treatment is completely inadequate for handling the sophisticated chemical pollutants common in modern wastewater. Nevertheless, about 30% of all communities in the United States rely solely upon primary treatment to clean sewage.

While primary treatment works on wastewater physically, the second part of basic treatment, the activated sludge process, brings biological processes into play. After the wastewater leaves the sedimentation tanks of primary treatment, it enters an aeration basin where it is mixed with air and sludge heavily loaded with beneficial bacteria. During the several hours that the mixture is held in the aeration basin, those bacteria break down many of the organic pollutants. The mixed liquor of wastewater and bacteria-laden sludge is then pumped to another sedimentation tank where solids settle out by gravity and are deposited on the bottom of the tank as sludge "activated" with bacteria. A portion of this sludge is recycled to the aeration tanks for mixing

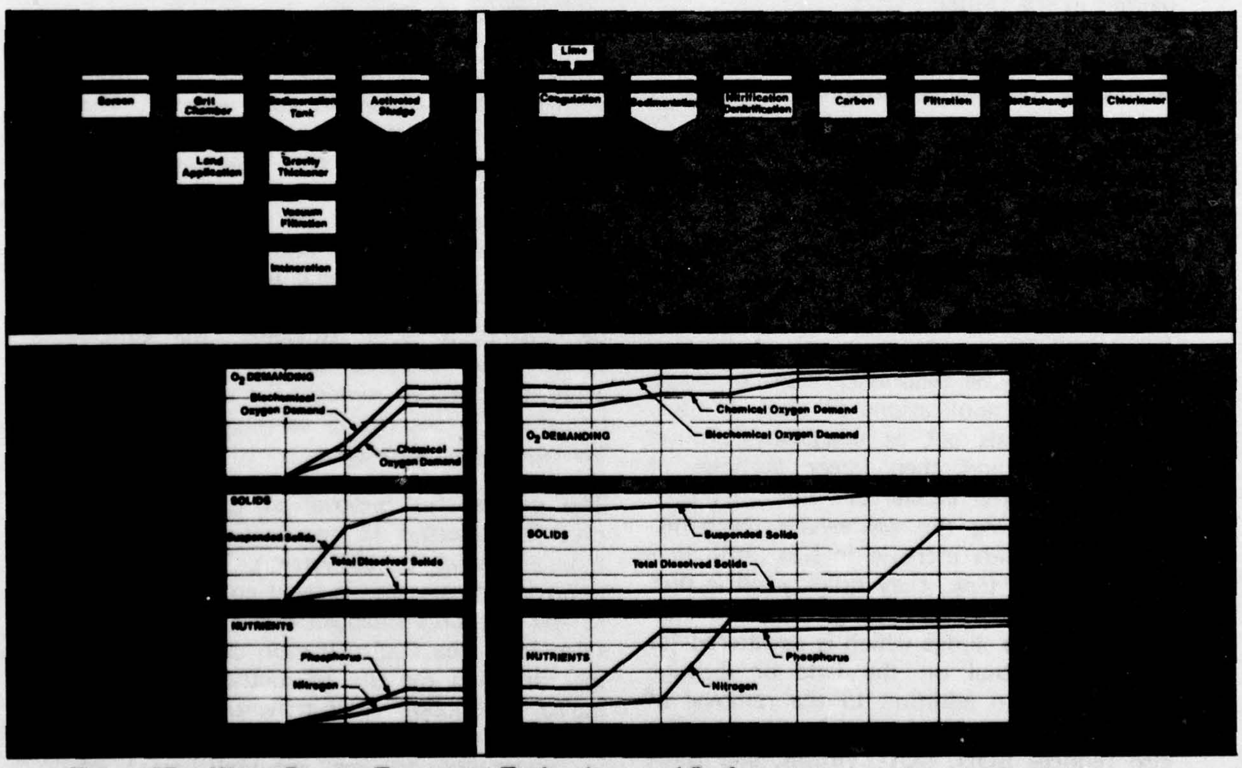


Figure 17. Water Process Treatment Technology and Performance

with incoming sewage and air to maintain the active biological community. When sedimentation is completed, the effluent can be chlorinated and discharged just as in primary treatment.

With the activated sludge process, the BOD and suspended solids removals increase to about 85% of the raw wastewater concentrations. That impressive advantage over primary treatment is certainly desirable, but activated sludge does have several limitations. First, it is vulnerable to toxic effects of some industrial waste components; the bacteria in the sludge can be killed outright and make an entire plant biologically inoperative. This difficulty is compounded by the fact that plant operators seldom know what the specific pollutants in incoming flows may be. And even if the composition were known, secondary treatment alone could not remove dissolved solids, heavy metals, or nutrients like phosphorus and nitrogen. Despite these problems, secondary treatment is the goal of 90% of the municipalities in the United States.

To deal effectively with the full range of wastewater pollutants, advanced treatment is required. The advanced systems commonly include four distinct operations: 1) coagulation-sedimentation; 2) carbon adsorption; 3) filtration; and 4) ion exchange.

Coagulation-Sedimentation

To remove virtually all remaining suspended solids and up to 98% of the phosphate, effluent from the secondary stage of treatment receives applications of alum or lime. These chemicals act as coagulants around which small and then larger particles of suspended matter cluster or "floc." By continuously mixing the wastewater mechanically, these solids increase in size until, in a sedimentation tank, they quickly settle out. The product of this coagulation-sedimentation phase is sludge which is dewatered for ultimate disposal on the land or through incineration. In addition to the removal of suspended solids and phosphate, this process also reduces BOD, COD, viruses, and some heavy metals.

Carbon Adsorption

This technique deals with the refractory organics remaining even after the coagulation process and produces effluent of high quality without any taste and odor problems caused by stubborn oxygen-demanding wastes. Adsorption occurs when incoming effluent passes through a column of carbon granules. Because these particles are many-faceted, they have enormous surface areas on which organic materials stick. To make this operation efficient and avoid clogging between granules, effluent can be pumped upwards through the column. The activated carbon particles themselves are cleaned by heat and reused.

Nitrogen Removal

Processes for nitrogen removal include ammonia stripping and microbial nitrification. Recent experience with plant-scale ammonia stripping systems have documented an inability to maintain high level process performance during the colder months of the year. This is attributed to the increased solubility of ammonia in water at low temperatures and to operational difficulties with stripping towers in cold weather. The aerobic nitrification sludge system appears to offer a more consistent year-round performance, although this system also suffers from some reduction in performance at colder temperatures. It also must be recognized that no operational experience exists for this process on other than the small scale demonstration level. However, the sludge system was selected as the process for achieving nitrogen removal for water process treatment in this study as it appears to be the best available process.

The process for removal of total nitrogen must be selected in conjunction with ammonia removal or conversion. The nitrogen removal process that is most complementary to the ammonia nitrogen conversion process selected is the denitrification sludge process incorporating the use of methanol for biological reduction (denitrification) of the nitrate compound. This process was selected in preference to the accomplishment of denitrification in the mixed media filter.

Filtration

More than a simple straining procedure, filtration removes suspended solids by adsorption and by trapping them on or between the particles of a porous medium like sand or coal. When the buildup of materials on the filtration medium begins to clog flow passages, the direction of the flow can be reversed. This backwash dislodges solid materials which are recycled to the coagulation basin for separation. When the resistance to flow has been sufficiently reduced, forward filtration may proceed. Here, the last residual of suspended solids is removed.

Ion Exchange

This is a process designed to remove the inorganic mineral salts dissolved in wastewater. Ion exchange units consist of resins containing ions, positively and negatively charged molecules, which can be replaced by similarly charged ions. Special acid resins will replace positive ions with hydrogen ions ($H+$), and base resins will replace negative ions with hydroxyl ions ($OH-$). These ions will then combine to form water (H_2O). Use of the above resins will reduce the dissolved mineral content instead of simply substituting one ion for another. When no more exchangeable ions are available, the resin becomes exhausted, and the contaminant appears in the effluent. At this point, forward flow is reversed as in filtration, and the resins are backwashed to remove collected contaminants. The resins themselves are then regenerated with a solution containing a new supply of the original exchangeable ion and treatment proceeds as before. Ion exchange can be extremely effective, but care must be taken to insure that the resins are not attacked by strong oxidants like chlorine. New techniques for treating brines produced in regenerating the resin include reverse osmosis which concentrates removed salts and makes their handling for transit to disposal areas or recycling far easier.

Brines are concentrated solutions of dissolved solids produced in the regeneration of ion exchange resins. These are the same dissolved solids which were previously present in the influent, but which were extracted and concentrated in the ion exchange process.

The dissolved solids removed on the resins come from many different sources. Some are present in the water initially; some are added as a result of municipal and industrial use; and some are added by wastewater treatment processes. The ocean is a compatible recipient for such high salt concentrations.

If the treatment site where the brines originate is located some distance from the sea, it will be necessary to retain the brines in small lagoons where the liquid portion would evaporate, due either to an artificial heat addition or natural solar radiation. The residue salts would then be removed after evaporation and stored prior to periodic transportation to the ocean for ultimate disposal at sea. Since these solids would redissolve in water, they must be kept dry during storage and transportation or they will be released to the environment in areas not compatible with such wastes.

Treatment Sequence

Properly designed and operated, wastewater treatment plants using all these processes in series can produce effluent of such high quality that it is suitable for drinking. For example, the city of Windhoek, South West Africa, troubled with inadequate water supplies caused by scant rainfall and brackish, foul-tasting surface water, has built a tertiary system which introduces its effluent directly into the municipal water supply. Each process in turn makes a particular contribution to wastewater renovation.

1. Primary treatment removes gross settleable material by screening and sedimentation;

2. Secondary treatment biologically removes many organic impurities;

3. Coagulation-sedimentation eliminates more discrete suspended solids, phosphates, and some heavy metals;

4. Carbon adsorption removes refractory organics and is used as a support process for nitrogen removal;

5. Filtration eliminates still finer suspended solids;

6. Ion exchange reduces dissolved solids concentrations to acceptable levels; and

7. Chlorination kills bacteria potentially dangerous to public health.

8. All steps from 3 through 7 reduce virus contamination.

The primary-secondary-tertiary sequence is extremely effective but its component processes can be arranged differently. The physical-chemical (P-C) process also produces thoroughly clean water. In this kind of system wastewater goes directly from partial primary treatment into coagulation-sedimentation by-passing secondary treatment completely. A major advantage of that short-circuit is that the biological activity in secondary treatment which is so vulnerable to changes in environmental conditions can be avoided. In a physical-chemical system, there are no bacteria sensitive to toxic substances, changes in flows or temperature fluctuations. The result is a more predictable efficient treatment operation.

In a physical-chemical (P-C) system, coagulation-sedimentation removes virtually all suspended solids and their associated BOD as well as dissolved solids like the phosphates in detergents. This stage of treatment differs from its counterpart in a tertiary system in the amount of coagulant added and the quality of sludge removed. In a P-C operation, moreover, there is no recovery of lime from the sludge. Sludge disposal may be either by incinerator or land disposal.

The denitrification process in the P-C system is also different from its tertiary counterpart, with the nitrogen treatment occurring in the carbon adsorption columns. Nitrogen (as ammonia) is removed by break-point chlorination. In this process nitrogen in the form of ammonia is converted to nitrogen gas for removal. Chlorine is introduced into the carbon columns as a gas where it reacts with the ammonia in the wastewater to form the nitrogen compound chloramine. Additional chlorine converts chloramines to molecular nitrogen, an insoluable gas which can pass off into the atmosphere from the cleansed effluent.

In physical-chemical treatment, the subsequent stages of filtration and ion exchange are performed precisely as in tertiary treatment.

Although P-C plants are not common, the technologies they employ are no longer experimental novelties. A plant at Lake Tahoe, using similar P-C processes on a secondary effluent, for example, has been operational since 1968 and treats a flow of 7.5 million gallons per day (mgd). A complete P-C plant to treat 60 million gallons per day is currently under design for the city of Niagara Falls, New York.

Summary

Figure 17 portrays graphically the water process treatment technology and its performance.

In primary treatment, solids are screened and settled out of solution. Some of those solids will contain oxygen demanding wastes. Secondary treatment will result in the bacterial breakdown of the organic matter containing oxygen demanding wastes. These wastes will be removed as the decomposed solid waste and bacterial sludge is settled.

In primary and secondary treatment, there are sedimentation tanks where the wastewater is allowed to rest for specific time intervals. In these tanks the suspended solids will settle and be removed as sludge. Very little of the stubborn dissolved solids can be removed in this fashion.

Although nutrients are found in the food chain of aquatic organisms and plants, those nutrients associated with cell growth do not represent a significant reduction in concentration through primary or secondary treat-

ment. The organic matter, now cells, is removed by settling.

Because the secondary effluent still contains suspended solids, those oxygen demanding wastes found in the solids remain to be removed. The solids may be coagulated and settled in the coagulation-sedimentation system. Those still in solution may adhere to the filter media in filtration or in carbon adsorption.

In coagulation-sedimentation, lime causes the suspended solids to coagulate into large settleable masses. Those solids still remaining will adhere to the filter media in filtration and carbon adsorption. Carbon adsorption removes those dissolved organics that create taste and odor problems; ion exchange reduces the dissolved inorganics.

In coagulation-sedimentation, lime makes the phosphorus insoluble and settleable. In Physical-Chemical chlorine is added to the carbon columns to convert the nitrogen to an insoluble gas. In Tertiary the nitrogen is biologically treated in the coagulation-sedimentation units so that it may be converted to an insoluble gas in the carbon columns.

Land Oriented Processes

Water-oriented primary, secondary, and tertiary/physical-chemical processes are not the only approaches to wastewater renovation. In addition to the treatments that discharge effluents into water, there are techniques which substitute the land as a treatment medium. To achieve basic treatment, for example, it is possible to use

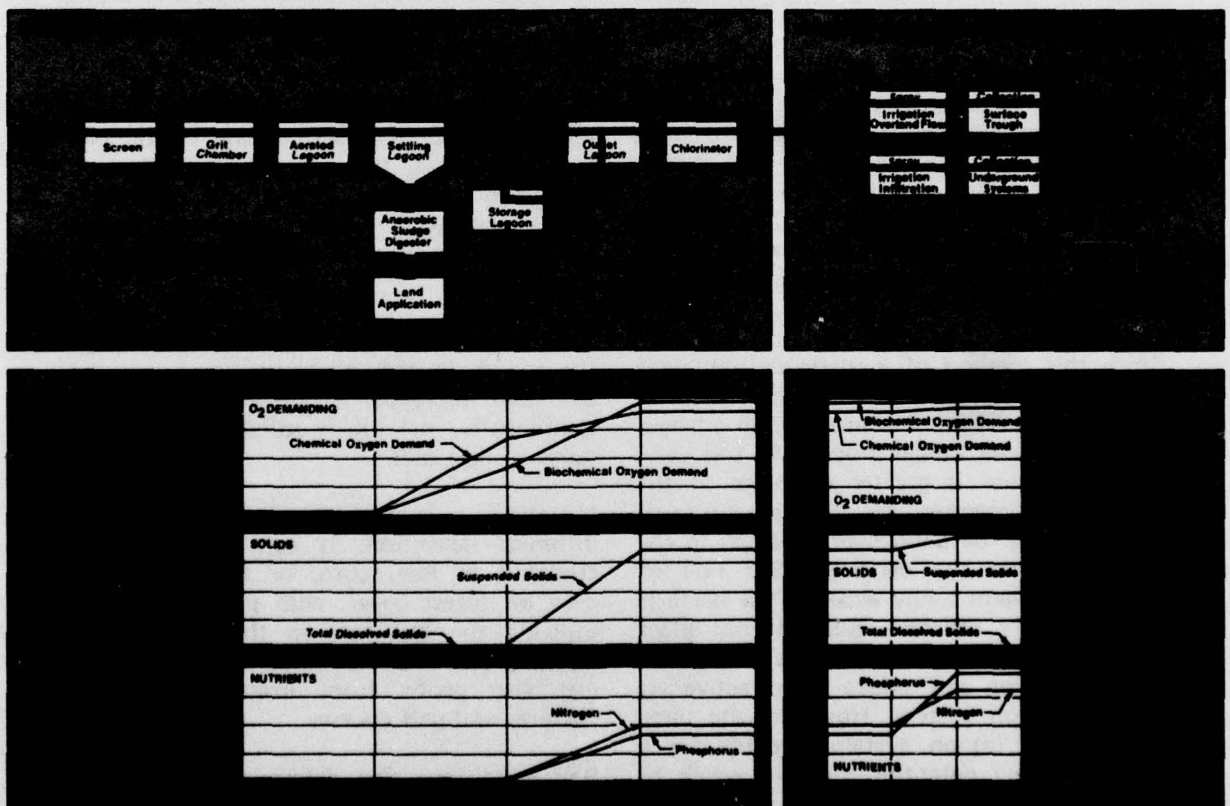


Figure 18. Land Application Technology and Performance

aerated lagoons interchangeably with the activated sludge process.

Treatment Lagoons

Lagoons are specially constructed ponds usually about ten feet deep in which algae, oxygen, and sunlight interact to oxidize organic wastes. Properly designed and operated, these lagoon systems can produce effluent water of secondary level quality.

In a land-disposal system, raw wastewater is first screened and then pumped into the lagoon where rotating units mechanically create a turbulence which insures a distribution of air. This promotes decomposition by those bacteria which require oxygen (aerobic bacteria). Without induced turbulence, those solids which will not stay in suspension settle to the bottom and are decomposed by bacteria which do not require oxygen (anaerobic bacteria).

After treatment in an aerated lagoon, the wastewater is pumped to a settling lagoon. Here decomposed solids are allowed to settle to the bottom and concentrate into a sludge. From the settling lagoon, effluent can go either to a storage lagoon for containment or to outlet lagoons, where more solids are deposited and chlorination eliminates pathogenic bacteria.

Since this method of wastewater treatment relies upon biological processes, it is sensitive to the same types of environmental changes as the activated sludge process. In this case, however, there is greater exposure of the treatment processes to the environment which cannot be controlled. Changes in the weather affect the decomposition rate of sewage; in warm sunny weather, the bacteria are extremely efficient. Sudden cold snaps or a succession of cloudy days can slow bacterial action and reduce the effectiveness of the lagoon system. However, the large size of the lagoon systems provide for a relatively long detention time in which to accomplish treatment, approximately three days. In addition, the size of the system would enable toxic spills to be isolated in one of the lagoon cells with the continuing wastewater diverted around it into adjacent lagoons which would continue to function. Moreover, bacteria are vulnerable to toxic wastes regularly or accidentally added to wastewater, and cannot remove complex inorganic or synthetic chemical compounds.

Spray Irrigation

When wastewater is to be cleaned by the land, three separate but interrelated issues must be taken into consideration; the nature of the land, the method of application, and alternatives for collection of the renovated water.

In the Codorus Basin the terrained units selected for land application are schist and phyllite. These units traverse the central basin on a southwest to northeast axis. Soil tests conducted in this terrain indicate an acceptable permeability, an adequate depth to the impermeable layer, and predominantly gentle slopes (less than 15%).

In an irrigation scheme, wastewater having received basic treatment in the lagoon system is pumped through standard irrigation equipment — pipes, risers, and nozzles — onto cropland or forest cover for eight months of the year at an application rate of 2" per week.

The irrigant infiltrates downward through the soil, both the vegetative cover and the soil itself improving the quality of the water significantly, making it suitable for a wide range of new uses.

Irrigation is compatible with a variety of different land uses. It can take place on cropland in hay, corn, or truck crops or even on forest cover, with plants and trees utilizing the nutrients in the effluent for faster growth. Other kinds of cleared land can also profit from irrigation such as pastures and golf courses.

Soil conditions also determine the method of collection for water cleaned by the land. On sand, there are two possible alternatives. Where the water table is less than six feet below the surface, an underground drainage

system of tiles can be installed to recapture water which has filtered through the ground. Where the water table is below six feet, it might be more practical to install wells at given intervals and simply pump ground water, including the renovated water to the surface. Whatever the method of collection, water cleansed by the land can be continuously monitored for quality and directed to desired uses.

The amount of nitrogen in the wastewater applied to the land is critical to the success of this kind of wastewater management. Since heavy concentrations of nitrogen are undesirable, loading or application rates have to be carefully controlled to be consistent with the ability of plants, bacteria, and soil particles to use or hold nitrogen. Plants and the soil utilize and store a portion of that amount. Ammonia forms will be denitrified by anaerobic bacteria in the soil or adsorbed to individual soil particles. Nitrates can be used as an oxygen source by bacteria to decompose organic material. Varying by the capacity of the site to use applied nitrogen, some portion may pass beyond the root zone and continue to move through the soils below. There is conflicting evidence about the amount of nitrate nitrogen which eventually might reach ground water. However, suffice it to say that sound wastewater management should aim at preventing or minimizing nitrate addition to the ground water.

Summary

Figure 18 portrays graphically the land application technology and its performance.

Because fish and other aquatic life must compete with oxygen demanding wastes for enough oxygen to sustain life, these wastes must be removed. Removal may be done biologically by aerobic bacteria that thrive in the lagoons. Solids containing the decomposed wastes are then settled to the bottom of the settling lagoons.

In the settling lagoon, the wastewater is at rest and the suspended solids are allowed to settle and concentrate into a sludge. Total dissolved solids, substances not decomposed by bacteria, are inorganic in character and will not settle out.

Nutrients are found in the food chain of aquatic organisms for support and stimulation of their growth. They also exist in a dissolved state in the wastewater. Those nutrients associated with the decomposed biological waste from the aerated lagoon will settle with that waste in the settling lagoon.

As wastewater flows through soil and vegetative cover in spray-irrigation, some of the solids will be filtered out of solution. Those oxygen demanding wastes that are found in the filterable material will be removed.

Various sized particles of sand, soil, and gravel, as well as vegetative cover, will act as filter media as spray-irrigated wastewater flows through it. Most of the remaining suspended solids will be filtered out. Dissolved solids will pass through the filter media along with the treated wastewater.

Nutrients are substances that are essential for plant growth. As wastewater flows through vegetative cover during spray-irrigation, the plants will remove the nutrients for fertilization of the plants' growth.

Special Cases

The kinds of water and land processes just described are usually applied to domestic sewage combined with flows of industrial wastewater and stormwater. However, some industrial process waters contain pollutants which could impair or destroy the operation of treatment plants if they were discharged directly into municipal systems. Other wastes contain process materials too valuable to discard. In these cases, industries attempt to elimate or must recover pollutants in-plant before process water is allowed to enter the larger environment.

Increasingly, industry recognizes that cleaning water used in manufacturing is a legitimate cost of doing business and that the responsibility for environmental quality does not leave the plant with the process water.

To meet that responsibility, manufacturers have several options. They can provide total in-plant wastewater treatment which produces effluent as clean or cleaner than water quality standards require. They can completely recycle wastewater and its pollutant components and produce no effluent at all. More often, though, industries will either pre-treat their wastewater and produce an effluent acceptable for further treatment in municipal systems or alter production processes themselves to use non-polluting materials less damaging to water or more easily removed.

In the Codorus Basin, major industries can eliminate a good portion of the gross pollution now discharged directly into the river by making use of one or more of these approaches. The first step toward that goal is to identify the pollutants associated with each type of industry and then apply the treatment techniques appropriate for their removal.

Pulp and Paper

Accounting for about three-fifths of the total industrial wastewater flow in the basin, the P. H. Glatfelter Paper Company in Spring Grove produces effluents containing suspended solids like bark and silt, soluble solids including both organics (sugars and carbohydrates) and inorganics (salts), and dyes. High BOD levels could overload the ability of a municipal wastewater treatment plant to handle organic materials and some of the fibers contained in the process wastewater could clog machinery in the municipal plant.

For most paper operations, therefore, pretreatment is a virtual necessity. Screening will catch large solids and grit will settle. Small bubbles of air can be introduced into the wastewater and as they rise to the surface, carry with them fine wood fibers which are skimmed off and recycled into the paper-making process. Finally, before being discharged for secondary treatment, the temperature of paper waste must be reduced and pH levels indicating acidity corrected. Whether or not basic treatment continues at the plant or in a municipal facility, tertiary treatment will be necessary to remove all traces of color and reduce BOD to minimum levels. Recycling in-plant is an attractive alternative because valuable by-products like turpentine, yeast, and alcohols can be recovered profitably. Dyes may require tertiary treatment to remove their intense color from wastewater.

Metal Plating

Perhaps most damaging in terms of the pollutants introduced into wastewaters are those from metal plating operations. Primary contaminants include chromium in its hexavalent form, sodium cyanide, and cyanides of heavy metals like nickel. In addition, the stripping and cleaning of metals produces strong acids and alkalis. All of these pollutants are highly toxic to man and most forms of aquatic life and, therefore, must be removed from wastewaters. In addition, metal plating wastes require pre-treatment before they can enter any municipal biological treatment system. Unless well-diluted, the metal content of settled wastes can interfere with sludge treatment processes and toxic metals can completely halt the biological reactions in the activated sludge process.

Cyanide treatment can be accomplished in several ways, one of which is through ion exchange. However, the most common technique is to raise the pH to about eleven and then destroy the pollutant cyanide by oxidation with chlorine gas. The treatment of chromium can be accomplished by reducing it from a toxic hexavalent form to a trivalent form and then precipitating it out with a lime slurry. In some systems, recycling may be possible. For example, rinse waters may be evaporated, the concentrate containing cyanides returned to the plating bath, and the distillate reused as rinse water. Other possibilities for recycling lie in concentrating and stockpiling the sludges produced by treatment, and later mining them for metals.

Stormwater

The other class of wastewater which requires special attention in the designs for a regional treatment system is stormwater, primarily in

the form of urban runoff. The treatment of stormwater is essential if the investment in the advanced treatment capacity and stream water quality is not to be jeopardized.

One approach to the problem would be to construct separate storm and sanitary sewer systems in cities and towns which now have combined collection systems, but even if the public could accept the disruption of opening every street and road in town, the cost in dollars would be astronomical. Another strategy – to construct treatment facilities large enough to handle regular municipal wastewater flows plus stormflows – would also require tremendous capital outlays to increase the capacity of treatment plants commensurate with increased stormwater flows.

The schemes presented in this report use still a third approach. The idea is to utilize detention basins into which stormflows can be channeled, prior to receiving treatment. These retention basins would store wastewater temporarily. During the retention period, aeration and sedimentation would take place. Having received the equivalent of primary treatment, the stormwater sewage mixture would then be pumped out of the retention basins over a period of fifteen days or less into the municipal treatment facility for complete renovation. This method of handling the stormwater sewage mixture is particularly attractive because of its flexibility. For example, during periods when parts of a treatment plant must be shut down to allow for maintenance, the storage system could temporarily store incoming sewage and industrial wastes. Moreover, in emergencies, the reserve capacity of surface basins can provide back-up space for wastes which would otherwise go directly into receiving waters.

PRODUCTS

For the municipal systems handling domestic sewage, pre-treated industrial wastes and stormwater, the principal products of wastewater are two: renovated water of extremely high quality and solid materials. The former is suitable for virtually all water uses and need only be directed to recreational areas, drinking supplies, etc. Solids or sludges removed in the course of wastewater treatment must still undergo further treatment before they too can be considered "treated."

Sludge Disposal

Primary sludges from sedimentation units are about 98.5 percent water and sludges produced by secondary and tertiary treatment are even higher in water content. The sludges must be thickened before dewatering can be accomplished. The thickening process is accomplished through mechanical stirring which produces clumps of more readily settleable sludge. The formation of these flocs or clumps is generally induced by the addition of lime or polymer coagulants. Even at best, however, water is very difficult to separate from its associated solids and it is not practical to thicken sludges to a solids concentration of more than 10 percent.

After thickening, the sludge undergoes a dewatering process known as vacuum filtration. In this operation, sludge is drawn by suction against a revolving drum that is partially submerged in a sludge tank. The drum is covered with a porous filter medium such as cloth, steel mesh, or tightly wound coil springs. As it rotates, most of the solids in the sludge slurry stick to the surface of the drum while most of the liquid passes through the filter medium. As the newly formed "filtercake" or residue emerges from the tank, it is air dried and then scraped with a knife edge onto a conveyer belt. As the filter drum continues to turn, it is washed with water spray to prevent clogging before it is immersed once again in the slurry tank.

With dewatering, the solids to water ratio in the sludge is raised to between 25 percent and 40 percent. At this stage, there are two alternative approaches to handling the sludge. It can be incinerated or distributed on the land improving soil structure and releasing nutrients to the vegetation.

In a physical-chemical treatment system, the solids in the wastewater which have been

separated from the liquid resemble the traditional raw and digested sludge of conventional treatment in some ways yet are quite different in other ways. For example, the density of a physical-chemical sludge is less than that of a conventional treatment unit. Due to the addition of aluminum or iron salts, the physical-chemical sludge is much higher in metal content than conventional sludges. Nevertheless, the solids in a physical-chemical sludge are similar to that from a conventional system in one fundamental area, specifically, that the solids removed remain as unstabilized organic matter. This provides a potential for odor problems.

The material in sludges from tertiary facilities has received sufficient treatment to remove the unstabilized organic material to such an extent that the threat of odor no longer exists in this case.

Two fundamental approaches to the stabilization of the physical-chemical sludge are available. First, there is the option of incineration of dewatered sludge with the sterile residue disposed of in a landfill operation. A second possible alternative deals with the digestion of sludge for stabilization of organic matter prior to dewatering and land application as a soil conditioner-fertilizer.

Incineration

Incineration which concentrates the sludge down to an inert ash is carried out in two steps. First, sludge is dried, i.e., heated to the boiling point with the water contained in the solids driven off as water vapor. Then, combustion takes place in the presence of fuel, high temperature, and air turbulence. Incineration products include an inert sterile ash and stack gases such as nitrogen, oxygen, water vapor, and carbon dioxide. With modern equipment and good management, these gases should not pose an air pollution problem. However, a monitoring program will be required wherever incineration is implemented in order to guide good operating practices.

Land Disposal

The other alternative for sludge handling is land application. Sludge is a source of plant nutrients as well as being a useful soil conditioner. Once dewatered, it can easily be spread mechanically on cropland, pasture, golf courses, and lawns. More manageable than liquid sludge, degested dried sludge can be applied at a rate of 25 tons per acre each year. At this rate, a total of 580 acres could handle all the sludge produced in the basin to the year 2000.

Although land application is not a new technique by any means, there are some precautions to be taken. When used on soils which produce vegetables or fruits eaten raw, it should be applied the previous fall, plowed under, and planted to a cover crop. On haylands, it may be spread in the spring or after hay harvest in early summer to avoid rejection of the grass by cattle.

The purpose of this chapter has been to present the technology now available to achieve clean water. Use of all components of the advanced waste treatment processes, either water or land, in proper sequence and configuration will yield maximum feasible water quality.

These processes are then the technological tools available. How these tools will be utilized, modified, constrained, and configured is not a function of technology, but rather of the planners who propose wastewater management systems and institutions which implement them. The stage is thus set for discussion of the planning accomplished by the Corps of Engineers and other involved agencies in the Codorus Creek Wastewater Management Study.

CHAPTER V PLAN FORMULATION

Introduction

Planning anywhere and for any purpose is preparation for action. In the Codorus Creek Wastewater Management Study, it was preparation for the action of providing a significant improvement in the quality of the waters of Codorus Creek. This chapter tells the story of the planning process in that study.

As described in Chapter II, the plan formulation process for the Codorus Creek Study was centered around a new concept in planning – one which would continuously incorporate the viewpoints of other governmental agencies and the general public, as well as provide a vehicle for keeping open future options for those who will be charged with implementing the study recommendations. Planning in this study used a dual formulation process – a process which provided on one hand for the display and screening of alternative solutions and on the other hand for a display of a range of technological choice responsive to the land application and water process treatment technologies of advanced wastewater treatment.

The primary focus of this chapter will be on the work done by the Policy Committee and the Citizens Advisory Committee. It will review in detail the screening process used by these groups to arrive at their recommendations and will demonstrate how these became an integral part of the basis for future choice.

The plan formulation process used in the conduct of the Codorus Creek Wastewater Management Study is portrayed graphically in Figure 19. Starting with the two basic concepts of advanced wastewater treatment (land application of treated effluent and water process treatment), ten conceptual displays were created, each responding to a known technological process of wastewater treatment. With these as a basis and guideline, selection criteria were developed. The two basic concepts of wastewater treatment, the ten conceptual displays, and the selection criteria were then used to formulate five alternative wastewater management plans.

The Policy Committee, with advice from the Citizens Advisory Committee, then began a screening process which was to lead to the formulation of a plan, later called the December Plan for the month when it was adopted. At the same time, the study staff was refining the plans which responded to the land application and water process treatment technologies. As previously stated, the end product of this process, as far as this volume of the report is concerned, is the "Alternatives For Choice." Recommendations relative to the "Alternatives For Choice" will be included in a supplemental report to be prepared after this volume has been reviewed by the involved agencies and a public meeting has been held.

Conceptual Designs

The identification and assessment of the water quality and related problems of the study area was a relatively easy step in the Codorus Creek Wastewater Management Study. The determination of technical and institutional solutions to these problems was not. Although the basic technology of wastewater treatment was understood, the concept of advanced wastewater treatment, with all its ramifications, was not.

The task which now faced the study participants was one of studying the broad range of alternative solutions to the water quality problems and identifying selection criteria which would be used to compare their relative advantages and disadvantages. It was decided that the best approach to accomplish this task would be to develop a series of alternatives (called conceptual displays) which would represent an application of each known technological solution to wastewater problems. This would establish a basis for reaction; it could help order values and goals; and it would display the system concepts available. But most importantly, it could allow the distillation, from individual

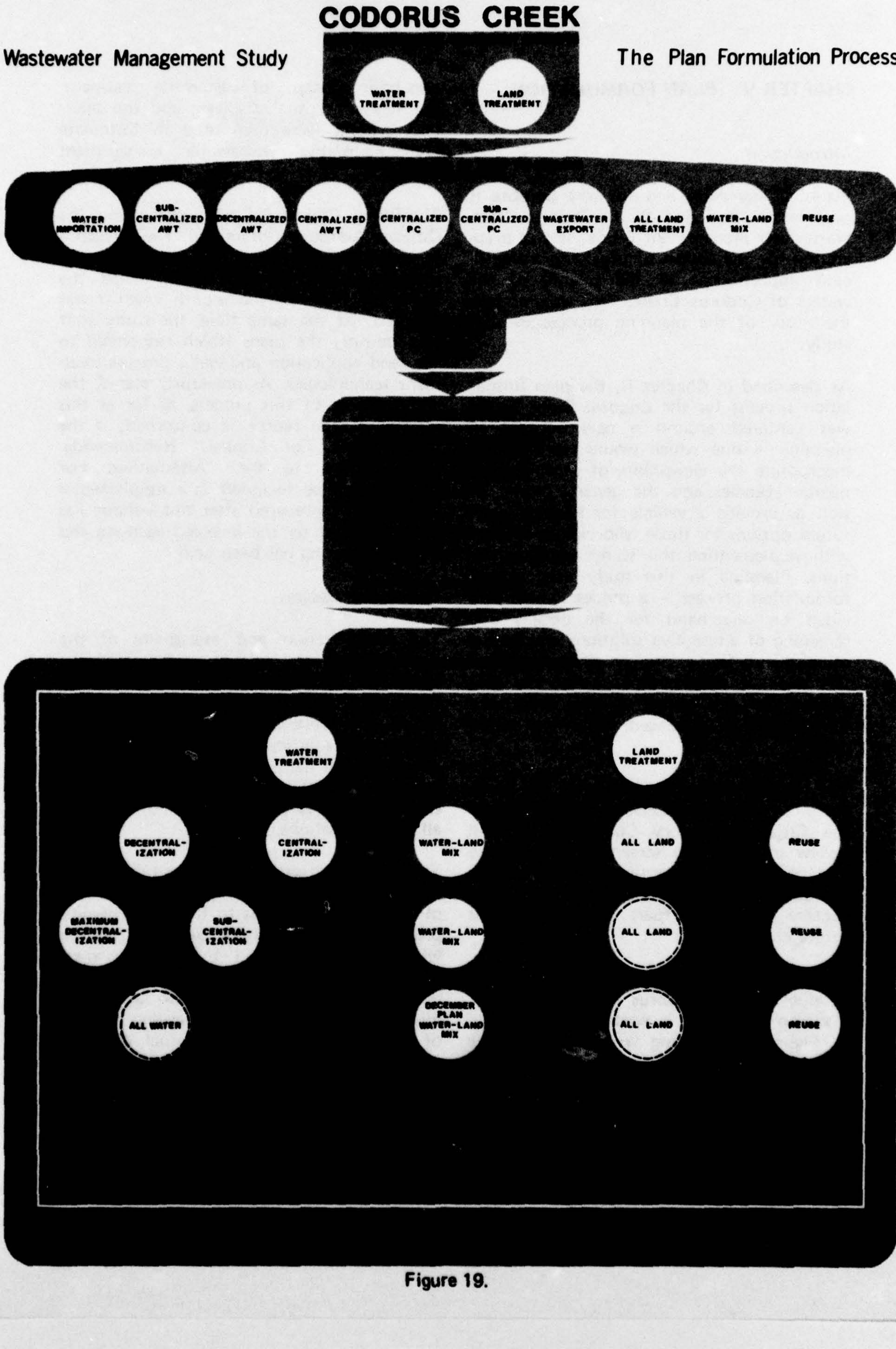

CODORUS CREEK
Wastewater Management Study
The Plan Formulation Process
WATER TREATMENT
LAND TREATMENT
WATER IMPORTATION
SUB-CENTRALIZED AWT
DECENTRALIZED AWT
CENTRALIZED AWT
CENTRALIZED PC
SUB-CENTRALIZED PC
WASTEWATER EXPORT
ALL LAND TREATMENT
WATER-LAND MIX
REUSE
WATER TREATMENT
LAND TREATMENT
DECENTRAL-IZATION
CENTRAL-IZATION
WATER-LAND MIX
ALL LAND
REUSE
MAXIMUM DECENTRAL-IZATION
SUB-CENTRAL-IZATION
WATER-LAND MIX
ALL LAND
REUSE
ALL WATER
DECEMBER PLAN WATER-LAND MIX
ALL LAND
REUSE

Figure 19.

thinking and group interaction, of the important features of the concepts – the features which give an indication of the individual or relative merits of a conceptual design. Then, at this point, selection criteria could be identified and used to further evaluate the alternative systems which were developed from these conceptual designs and also to highlight the subject areas where additional information would be required for future screening.

Beginning with the two basic wastewater treatment concepts of water process treatment and land application treatment, ten conceptual displays of possible solutions to the water quality problem were formulated and presented to both the Policy Committee and the Citizens Advisory Committee. These initial alternatives were in keeping with a goal of the study to present a full range of treatment technology.

The ten conceptual displays are as shown in Figure 20 and are described below:

1. Water Importation – A pipeline would bring water from the Susquehanna River to points in the upper reaches of the basin to increase streamflow and thus to dilute the concentration of pollutants.

2. Sub-Centralized Advanced Treatment – Advanced water process treatment plants would be constructed for each of the major urban centers.

3. Decentralized Advanced Treatment – Advanced water process treatment plants would be constructed for each population center.

4. Centralized Advanced Treatment – One advanced water process treatment plant would be constructed to service the entire study area.

5. Centralized Physical-Chemical – One advanced physical-chemical plant would be constructed to service the entire study area.

6. Sub-Centralized Physical-Chemical – The upper basin would receive service from a physical-chemical plant; the lower basin from an advanced water process treatment plant.

7. Out-of-Basin Diversion – After secondary treatment, wastes would be piped from a central facility directly to the Susquehanna River.

8. All Land Disposal – All study area wastewater would be applied to the land for advanced treatment.

9. Land-Water Combination – Upper basin wastewater would be spray irrigated; lower basin wastewater would be treated at an advanced water process treatment plant.

10. Reuse – Treatment plant effluent would be reused as process water supply for P. H. Glatfelter.

These ten were presented in conceptual form only. This was necessary for two reasons: first, at this point in the study, planning was in its early stages and the descriptive system parameters, such as cost, performance, and configuration were in very preliminary form; and, more important, the intent of presenting these conceptual displays was not to immediately find the best solution, but, as noted before, to identify selection criteria which could be used both to refine the alternatives and to make decisions on plan formulation at future points in the planning process.

Selection Criteria

After thorough discussion, evaluation, study, and critique of the ten conceptual displays, it was possible to identify selection criteria. The conceptual displays still remained to be used further in the planning process as will be seen later.

The following selection criteria were identified which would be used for future evaluation of alternatives:

1. National Economic Development.

2. Regional Development.

3. Environmental Quality.

4. Social Well-Being.

5. Technology.

6. Water Quality Goals.

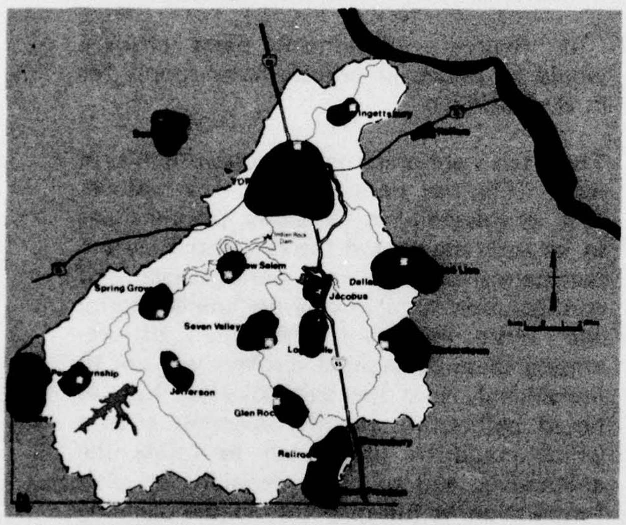
7. Centralization.

8. Reuse.

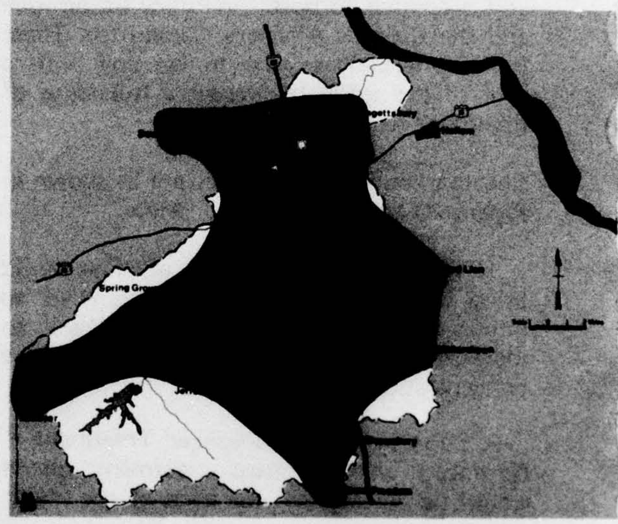
9. Institutional Arrangements.

Before discussing each in turn, two points must be made about the criteria array. First, the listing represents a composite governmental/public/private view. Within this composite view, however, was a melding of differing emphasis and priority. Although some criteria were felt to be of prime importance by one group, others may have relegated the criteria to a secondary position. All of which is to say that the criteria were not weighed equally from agency to agency or level to level. The second point is similar to the first and is that within a

Figure 20:
Conceptual Displays

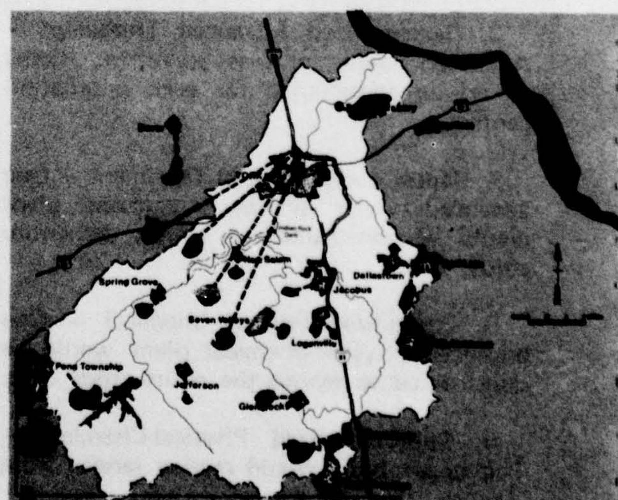


3. Decentralized Advanced Treatment

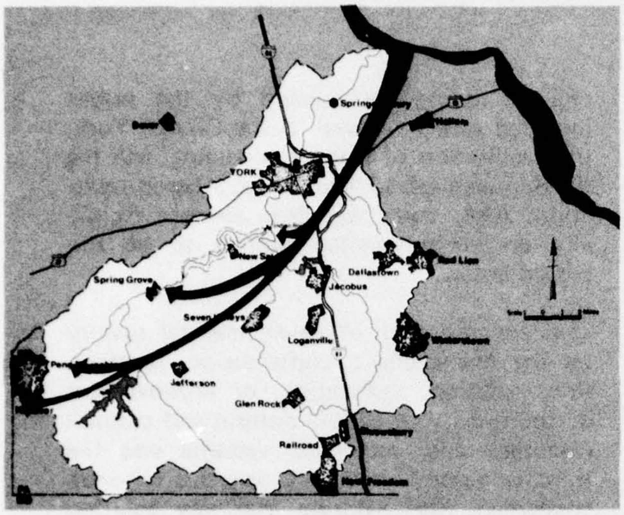


4. Centralized Advanced Treatment

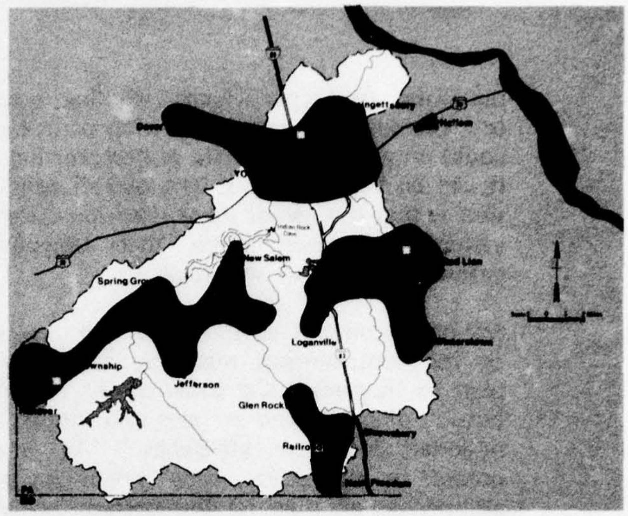
7. Out-of-Basin Diversion



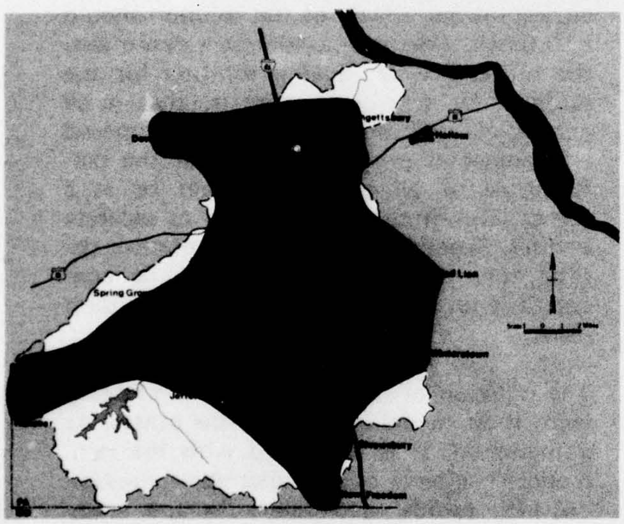
8. All Land Disposal



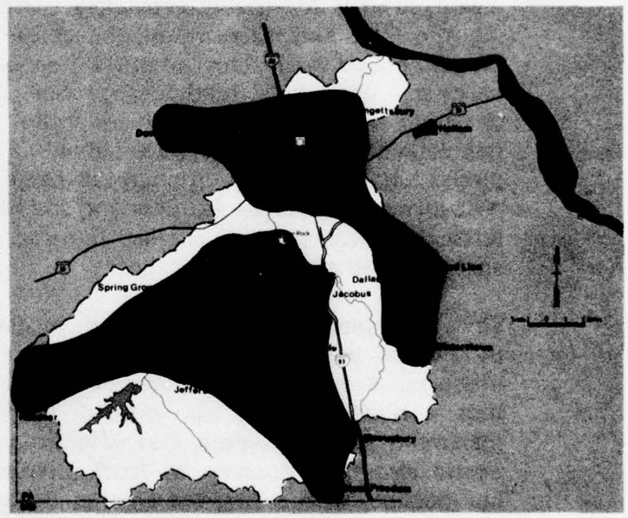
1. Water Importation



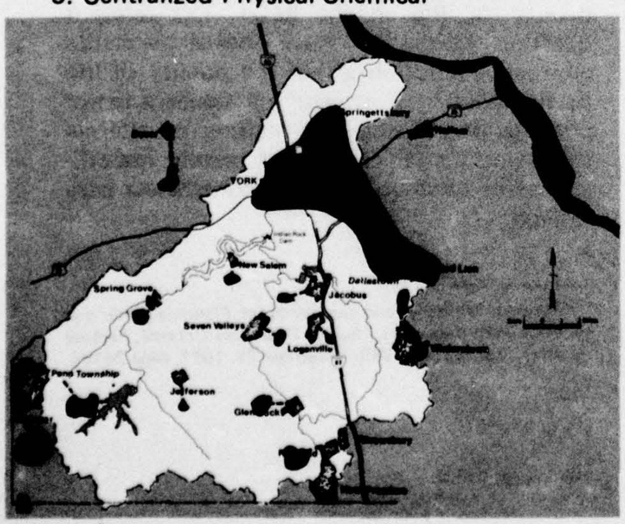
2. Sub-Centralized Advanced Treatment tment



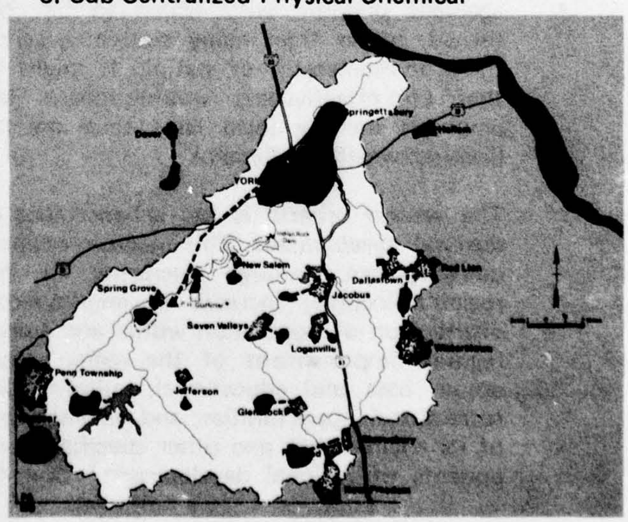
5. Centralized Physical-Chemical



6. Sub-Centralized Physical-Chemical



9. Land-Water Combination



10. Reuse

particular study participant, whether group or individual, the relative ranking of criteria could only be approximate at best, resting as it did on value systems. The overall conclusion is that the use of these selection criteria yielded subjective, more than objective, evaluations of proposed solutions.

National economic development is a measure of the contributions made by a particular plan to increasing the value of the nation's output of goods and services and improving national economic efficiency.[1] As interpreted in the study, this meant judging alternatives on their relative costs to achieve a certain objective, specifically a desired treatment performance level. In effect, this meant striving for cost-effectiveness – finding the least expensive means to achieve a predetermined goal. This interpretation was necessary because a methodology has not yet been devised to accurately quantify all the economic effects of water quality improvement. Thus, any attempt at benefit-cost analysis would be fruitless and the best remaining criterion of similar purpose is cost-effectiveness.

Since any plan would be financed, in part, by Federal and most likely Commonwealth interests, it was a logical concern of both that cost-effectiveness be pursued to the maximum extent possible. Cost-effectiveness would also be a concern to local interests, but possibly with a different emphasis. Since they would have only one wastewater management program with which to be concerned, rather than many stretching across the Commonwealth or nation, it might be that cost-effectiveness would receive less emphasis on the local level than on the Commonwealth or Federal.

The second criteria is the enhancement of *regional development*. This includes regional development through increases in the region's income; increase in employment; distribution of population within and among regions; improvement of the region's economic base and educational, cultural, and recreational opportunities; and enhancement of its environment and other specified components of regional development.[2] Specific regional desires articulated by the public included urban renewal in the City of York, the facilitation of land use planning, and the development of additional water-based recreation. Also, there was deep concern regionally on environmental matters to be discussed below.

The enhancement of *environmental quality* by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems was the third criterion.[3] Not only was this criterion concerned with assuring that any solution met the objective of a significant water quality improvement, but also that the other environmental effects of the solution should be known. Also expressed was a desire that the ultimate water quality solution for the Codorus be synergistic, that is, that it be compatible with other ongoing and proposed environmental programs such that the performance of all programs would be at a higher level in combination than as separate entities. Specifically, local representatives desired that the water quality plan be consistent with solid waste and air pollution plans.

The criterion of *social well-being* less readily lends itself to definition than the others. As a minimum, it is concerned with the non-monetary effects of any alternative solution on life, health, and safety in the study area.[4] It is a subjective measure of the total quality of life in the basin. The relevant question would be "How does a particular alternative solution affect the quality of life in the basin?" This criterion serves a major purpose of insuring that features of alternative solutions which are not readily identifiable with other criteria are nonetheless considered.

[1] "Proposed Principles and Standards for Planning Water and Related Land Resources," Water Resources Council, *Federal Register*, Vol. 36, No. 245, December 21, 1971, page 24145.

[2] Ibid.

[3] Ibid.

[4] Ibid., page 24146.

The criterion of *technology* encompasses the ability of the proposed systems to attain the water quality objectives; the reliability of these systems; their economic life, their operation, maintenance, and replacement requirement; their salvage value; their physical configuration and land requirements; and their compatibility or effect on existing wastewater treatment systems.

Water quality goals were the most difficult criterion of all to articulate. There were established Commonwealth water quality standards which could have been adopted as goals. But what was asked of the study participants and what they had to ask themselves was "Do we wish to adopt higher water quality standards for the region, and if so, what should they be and why?"

Several factors had bearing on the selection of water quality goals. First, there was a definite need for water quality improvement and an expressed desire to return the Codorus to its natural state. Second, there was a realization of the national trend toward clean water, as evidenced by the pending Congressional bills on water quality. Finally, there was the desire to free Codorus Creek from its man-imposed constraints, so that the opportunities promised by clean water such as augmented water supply, urban renewal, and recreation could be realized.

The crucial input for the decision on the water quality goals was provided by the Citizens Advisory Committee, representing the residents of the study area. While the Corps of Engineers certainly promoted the cleanest possible water and was interested in displaying the benefits of clean water, a position in which they were joined by the Environmental Protection Agency, neither the Corps nor EPA had the authority or responsibility to set water quality standards. The Commonwealth, by law, had this right and consequently had already set standards. Their position was that the Codorus Basin was required to meet only the existing standards, though they would not object to the citizens of the basin adopting higher ones. Thus, any initiative for setting higher standards would properly have to come from local interests. The Citizens Advisory Committee took the initiative and opted for higher levels of pollutant removal, specifically to include the removal of the nutrients, nitrogen and phosphorus.

This goal did not specifically set an optimal level for each water quality parameter, a task which may not be possible, even given present day knowledge. It did, however, give guidance for the technical formulation of alternative solutions. Further, it did provide a criteria by which to judge these alternative solutions.

Centralization was adopted as a criterion because of possible economies of scale from a multi-service area system. The study participants realized that in certain situations it could be less expensive to construct, operate, and maintain one or more large treatment systems than several small ones. It was also realized that management of a single system had distinct advantages over management of many systems, e.g., centralized operational control could yield efficient system performance with increased reliability. Thus, it was held that centralization should be examined closely when reflected in alternative solutions.

Reuse is the concept of recycling waste resources to make them usable again and thus, in effect, conserving the resource. All participants agreed on the merit and potential of this concept when applied to wastewater. To this end, they desired to see reuse presented as one of, or part of, the alternative solutions, and thus it became a selection criterion.

Reuse was particularly promising in the study area due to the location there of the P. H. Glatfelter Paper Company, the major industrial water user in the basin. First thoughts on reuse revolved around the working hypothesis that treatment plant effluents could be used at Glatfelter rather than being disposed of in the streams. Given this, then the water supply which Glatfelter presently uses could possibly be freed for other uses such as domestic water supply and recreation, which would ameliorate some of the study area's water resource needs.

The ninth and final criterion was *institutional arrangements.* This criterion was intended to measure the relative ease or difficulty of institutionally implementing and managing a proposed wastewater treatment system. Since it was envisioned that local institutions could face a major challenge in implementing a comprehensive wastewater management plan, it was desired to determine what institutional change would be required and how it could be effected.

With the establishment of the criteria above, two major tasks had been accomplished. First, a vehicle had been devised whereby the ten conceptual displays could be refined and put into the form of viable alternative plans. Second, the selection criteria highlighted areas where there was a significant lack of required information, such as institutional arrangements, soil and water quality data, and additional technical performance information on advanced wastewater treatment processes. The next step was then to simultaneously formulate alternatives and acquire the required information.

Formulation of Alternative Solutions

Based on the two treatment concepts of advanced water process treatment and land application and by applying the selection criteria to the ten conceptual displays, a set of five significantly different alternatives was developed and submitted to the Policy Committee. The five alternatives are shown in Figure 21 and described below.

1. *Centralized Water Treatment*: Generally, a centralized collection and treatment system with discharge to either the Susquehanna River or to Codorus Creek below York. Presented with several options which varied the treatment levels, the degree of centralization, and treatment technology.

2. *Decentralized Water Treatment*: Treatment to various treatment levels at existing or presently programmed local treatment facilities with discharge to the closest streams.

3. *All Land Treatment*: Primary and secondary treatment of all wastewater followed by land application of secondary effluent.

4. *Combination Land-Water Treatment*: Land application in the Upper Basin; advanced water process treatment for the York Urban Area.

5. *Reuse*: Reuse of York Urban Area secondary effluent as industrial process water supply by the P. H. Glatfelter Company in Spring Grove. After reuse, final effluent would receive either land application or advanced water process treatment.

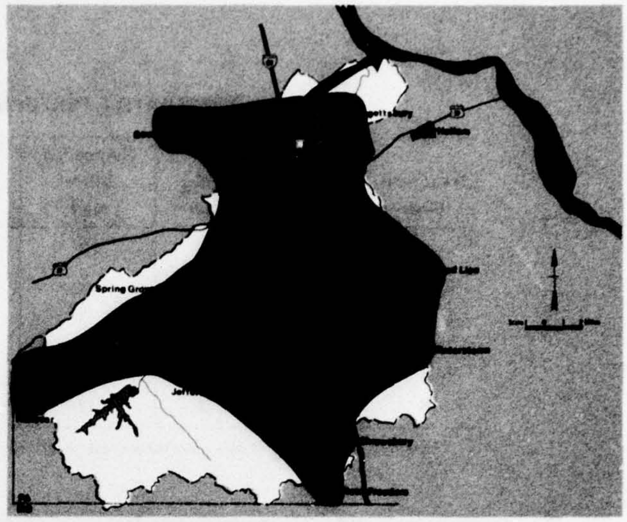
Conspicuously absent from these five alternatives, but present in the ten conceptual displays, is the importation of Susquehanna River water for wastewater dilution. This omission is a result of the Policy Committee's first application of the selection criteria to the plan formulation process. Analyzing the conceptual displays, it was obvious to the entire committee that wastewater dilution was not an acceptable answer to the wastewater management problem of the Codorus watershed, especially when considering the effects of water pollution on the Susquehanna River. Such a solution might have improved the quality of Codorus Creek but would have produced no improvement downstream. Thus, the Policy Committee, with full concurrence of the Citizens Advisory Committee, decided against a measure which obviously represented a transfer of the problem more than a solution. The concept was not acceptable under the criterion of environmental quality.

Acquisition of Additional Information

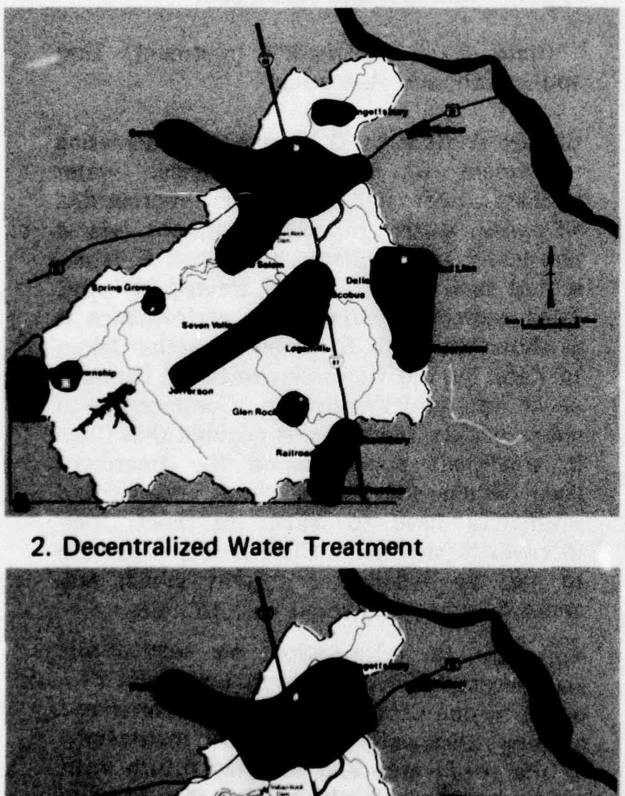
In order to utilize the established selection criteria in further screening of alternative solutions, certain information was gathered and prepared, both in a technical and nontechnical vein.

The technical information consisted of soil investigations performed by the Corps of Engineers, a water quality survey done by the Environmental Protection Agency, and

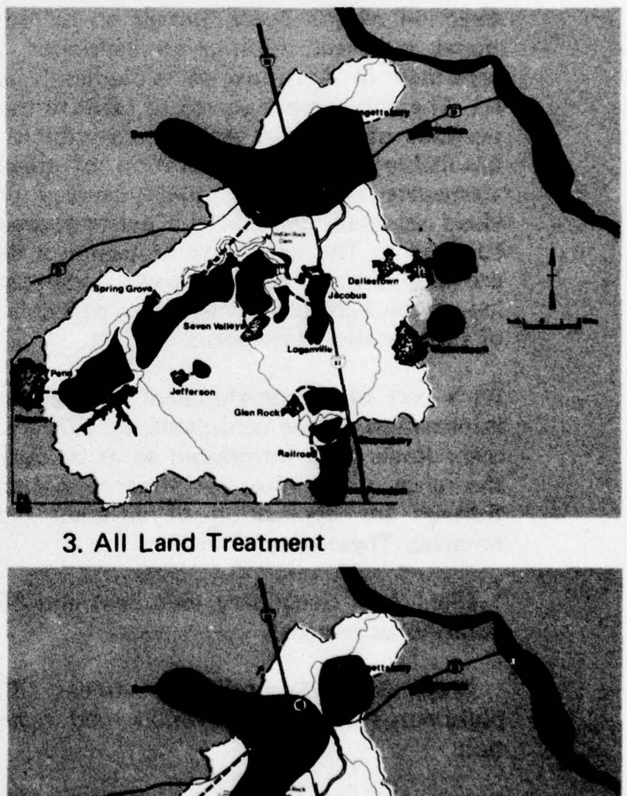
Figure 21. Alternative Plans



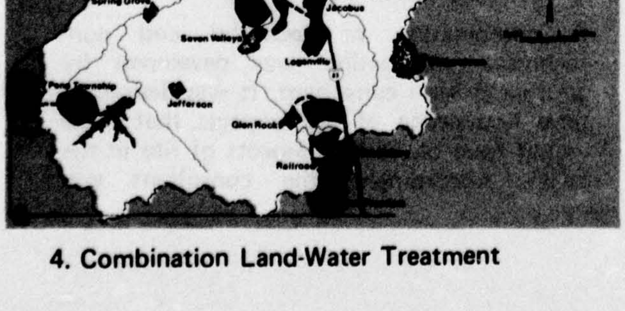
1. Centralized Water Treatment



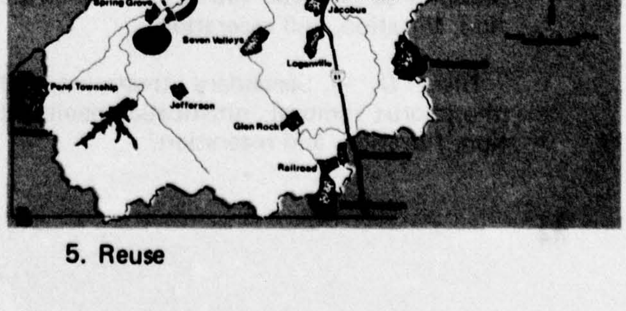
2. Decentralized Water Treatment



3. All Land Treatment



4. Combination Land-Water Treatment



5. Reuse

TABLE 5

COMPARATIVE PERFORMANCE OF TREATMENT CLASSES*

Treatment Class	COD mg/l	BOD_5 mg/l	Suspended Solids mg/l	Dissolved Solids mg/l	Phosphorus % rem./ mg/l	NH– N^3 mg/l	NO NO_2^3-N mg/l	Organic N mg/l
A	90	30	20	400	80/2	17	1	2
B	45	7	3	400	80/2	17	1	2
C	30	5	3	400	80/2	0	2	0
D	30	5	3	350	98/0.2	0	2	0
E	10	3	3	350	98/0.2	0	2	0
F	5	3	0	400	99/0.05	0	2	0

*Effluent concentrations in milligrams per liter (mg/l). Phosphorus also shown in terms of percent removal.

expansion of treatment technology data accomplished by a private consultant under direction of the Corps. Details on the additional technical information developed are presented in Appendix A, Volumes II and III. The soil surveys served to identify those portions of the area which were suitable or unsuitable for land application of treated wastewater. The water quality survey provided updated data on the existing stream conditions. The expansion of technical data provided a more comprehensive understanding of the available technologies, particularly of their relative differences.

As a part of the development of additional information by the consultant, specific treatment levels were introduced so as to clarify the range of technical performance available through the application of different technologies. These were:

Class A – Secondary treatment and 80% phosphorus removal.

Class B – Secondary treatment, 80% phosphorus removal, filtration, and reaeration.

Class C – Secondary treatment, 80% phosphorus removal, nitrification-denitrification, filtration, and reaeration.

Class D – Secondary treatment, 98% phosphorus removal, nitrification-denitrification, filtration, and reaeration.

Class E – Physical-chemical treatment system, filtration, and reaeration.

Class F – Secondary treatment, land application, and reaeration.

Classes A through D represented increasing refinement of biological advanced water process treatment, Class E represented advanced water process treatment via a physical-chemical plant, and Class F represented land application of treated effluent. Their expected comparative performance is as shown in Table 5. Based on action taken to date by the Commonwealth of Pennsylvania in implementing a Commonwealth water quality plan, it was decided that Class B treatment approximated the treatment level which the entire study area would ultimately have to attain to meet Commonwealth standards. Class B was thus held to be the baseline condition which any water quality plan would have to meet.

Non-technical information on institutions was developed in a research document prepared by the Corps of Engineers. It analyzed existing wastewater management institutions in the study area and outlined future institutional options available. This document is included as Appendix C.

A combination of technical and non-technical information was developed by another private consultant. It was desired to have knowledge of the impacts that plans would have on various aspects of life in the basin. Accordingly, the consultant was

directed to perform impact assessments which reported on four categories of impacts: socio-economic, visual, aquatic ecology, and terrestrial ecology. Simultaneously, a public health impact assessment was performed by the U.S. Public Health Service. The concepts for which the impact assessments were performed were decentralization, centralization, water process treatment, land application, and reuse. Additionally, the impacts of Class B and Class D treatment were studied. Class B approximated the existing Commonwealth standards; Class D reflected treatment approximating the highest levels possible under existing technology.

The most important category of required information was the views and feelings of the public on the study and its objectives. Providing this information was the Citizens Advisory Committee. Through frequent contact with the people they represented, indications of areas of concern were relayed to the Policy Committee so that these concerns could be responded to, either through further explanation or by modification of the planning concepts. Typical concerns were the relationship of the study to Commonwealth water quality policy and the implications of land application.

With the movement from the conceptual displays to the five alternatives and with the concurrent development of additional information, formal screening of alternatives using the now refined selection criteria was possible. The starting point was again the two concepts of advanced wastewater treatment — water process treatment and land application.

Screening of Alternatives

The actual screening of alternatives was accomplished through periodic meetings of the Policy Committee. At each committee meeting some alternatives would be discarded; the remainder would be retained for further study; before the next meeting, the study team would analyze and refine the remaining alternatives; and so on in this iterative process, until the Policy Committee had developed the December Plan, named for the month of its adoption. This, generally, was the procedure followed, except that the Corps directed its study staff to retain the two polar treatment concepts, i.e., an all water treatment plan and an all land treatment plan, throughout the plan formulation process and to refine these two plans along with the alternatives retained by the Policy Committee. It was decided that to do otherwise would preclude the opportunity for future choice near the end of the study when the most accurate cost and performance data would be available.

Concurrent with these Policy Committee meetings, the Citizens Advisory Committee was also holding meetings to review the alternatives, to review the actions of the Policy Committee, and to formulate a set of study recommendations to the Policy Committee.

The lower portion of Figure 19, shown again in Figure 22, schematically depicts the screening process. Starting with the first five alternatives, the solid directional lines show the selection of a particular alternative for further study and refinement and the dashed directional lines indicate the elimination of alternatives by the Policy Committee. Note, however, that those eliminated were carried forward and refined by the study team to obtain the polar water and land treatment alternatives. Figure 22 shows, therefore, that the all land application plan was eliminated at one point in the screening process by the Policy Committee but retained for further refinement by the study team. The Policy Committee screened out the all land plan primarily due to estimated cost. Concerns were also voiced over the potential disruptive social effects resulting from land acquisition.

Figure 22 also shows the subsequent screening out of the two all water process treatment plans. This was done mainly because the Citizens Advisory Committee's preference for a plan which employed the land application technology and because, after eliminating the all land system, the combination land-water plan seemed at that time to be the most cost-effective means of achieving a high level (level D or better) of treatment performance.

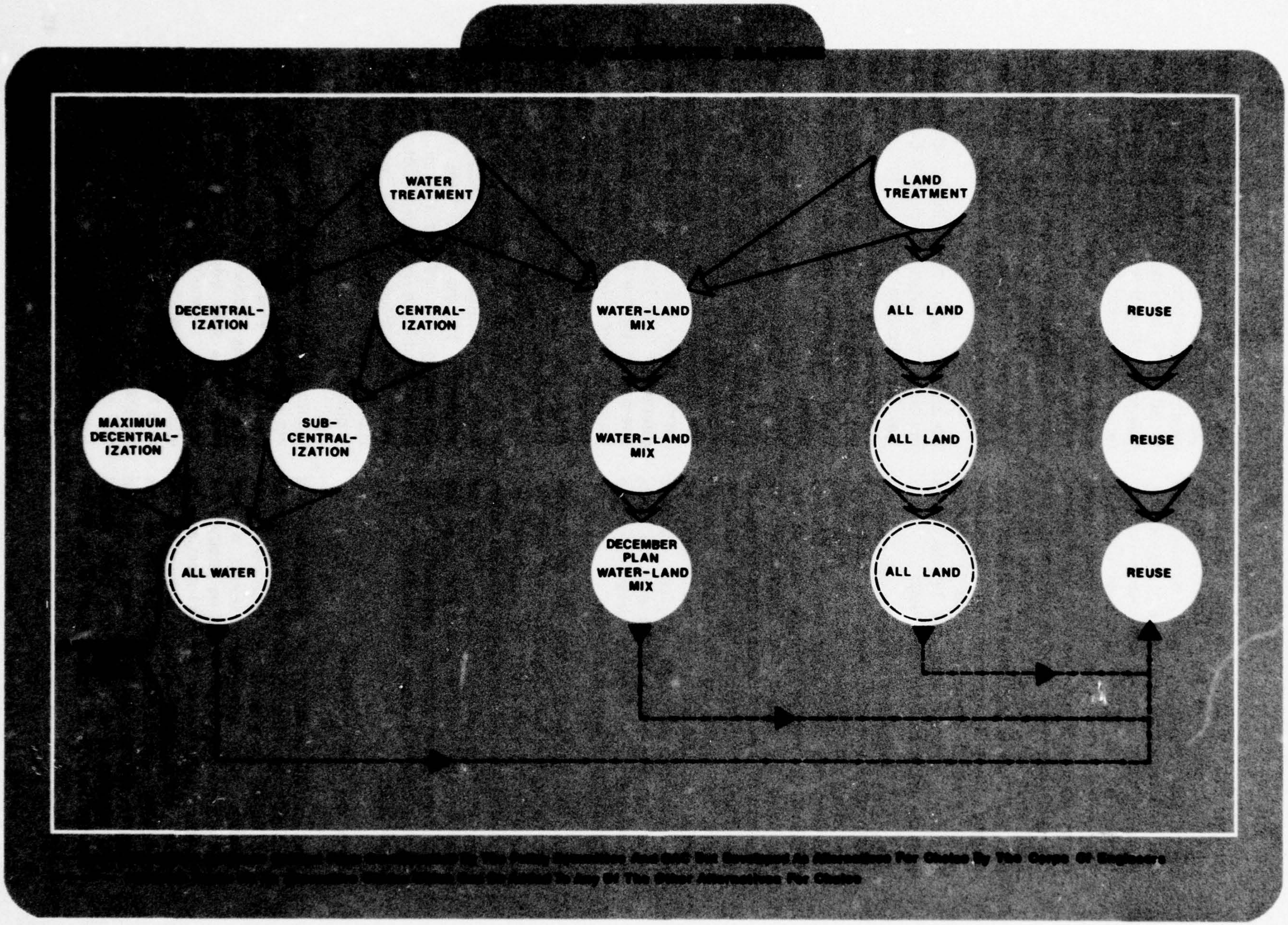

WATER TREATMENT
LAND TREATMENT
DECENTRAL-IZATION
CENTRAL-IZATION
WATER-LAND MIX
ALL LAND
REUSE
MAXIMUM DECENTRAL-IZATION
SUB-CENTRAL-IZATION
WATER-LAND MIX
ALL LAND
REUSE
ALL WATER
DECEMBER PLAN WATER-LAND MIX
ALL LAND
REUSE

Figure 22.

TABLE 6

EVALUATION OF ALTERNATIVES IN THE SCREENING PROCESS

Selection Criteria	Centralized Water Treatment	Decentralized Water Treatment	All Land Treatment	Combination Land-Water Treatment	Reuse
Natl Econ Dev (Cost-effectiveness)	+	+	–	+	+
Regional Development	+	–	+	+	+
Environmental Quality	+	N	+	+	+
Social Well-Being	+	+	–	+	+
Technology	+	N	+	+	+
Water Quality Goals	+	+	+	+	N
Centralization	+	–	+	+	N
Reuse	N	N	+	+	+
Institutional Requirements	–	+	–	–	–

\+ = Positive Response
– = Negative Response
N = Neutral Response

NOTE: Entries in this table reflect judgments made based upon information available a point in time – information which changed later in the study.

Though the foregoing has provided a description of *how* the planning process arrived at the December Plan, there has been little discussion of *why* the decisions leading to this plan were made. Ultimately, these decisions were based on the responses of the various alternatives to the selection criteria at a given time in the plan formulation process. Table 6 displays the responses of the set of five alternatives to the selection criteria.

It *should be remembered* that Table 6 represents evaluation done *during* the planning process, not at its end. As such, the information upon which judgments and decisions were based was the best available at the time. More refined and complete information was developed as the study progressed.

In interpreting Table 6, responses of the alternatives to a specific criterion (horizontal entries) will be discussed first. It will be followed by an overall evaluation of the response of a particular alternative to all selection criteria (vertical entries). Alternative responses to specific criteria are relative, that is, one entry is made in consideration of the other four.

Alternative Response to Specific Criteria

The significant entry for the National Economic Development (Cost-Effectiveness) criterion is the minus for All Land Treatment. Preliminary cost estimates showed that the capital cost of this alternative ($103,000,000) was at least $35,000,000 or 52% higher than the next most costly alternative (see Appendix A, Volume III, Page III-69). The other alternatives were competitive in cost, ranging from $56-$68 millions for high level treatment.

For regional development, the only alternative which was viewed as not making a significant contribution was the decentralized water treatment alternative. In effect, this proposal called for a continuation of the status quo in the study area. There would be no true regional approach to wastewater management, rather an incremental, piecemeal strategy. Though there would be some local improvement in environmental conditions, compared to the other alternatives, the decentralized system did not offer nearly as much potential for increases in regional income, employment, or educational, cultural, and recreational opportunities.

All systems responded to the criterion of environmental quality. Alternative 2, however, provided the least potential for linking progress in water quality control with other aspects of environmental improvement. Thus Alternative 2 was held to be neutral vis-a-vis environmental quality. While it certainly did not hinder the achievement of clean water, the others provided more opportunities for a greatly improved total natural environment.

For the criterion of social well-being, the All Land Alternative was felt to include potential negative effects, particularly in terms of uncertainties as to its impacts due to lack of experience with this technology in the local area. The uncertainties include household relocations, loss of tax base, and reduced land use opportunities. Alternative 4, since it included some land application, was subject to the same negative effects. However, its land requirement was much smaller and the negative effects correspondingly lessened. For this reason, Alternative 4, along with Alternatives 1, 2, and 5 were judged as having a beneficial response to social well-being.

Alternative 2 was felt to have a neutral response to the criterion of technology. What was desired was to employ existing advanced wastewater treatment technology in the most beneficial manner. Though decentralized water treatment would indeed utilize existing technology, it would not do so to the extent of the other four alternatives. Where it merely added on processes to existing plants, the others offered entirely new plants and systems. Given that the existing systems had still left the area with a water quality problem, there was some feeling that major new systems, rather than improved old systems, might yield better results. Utilizing this rationale, the other four alternatives had a positive response to the technology criterion.

The criterion of water quality was met by all alternatives, the neutral entry for reuse indicating that this alternative in reality was a possible addition to any alternative.

The centralization criterion was not met by Alternative 2, since it was formulated primarily as an alternative to this concept. Economies of scale foreseen by combining service areas and treatment systems could not be realized by decentralization. Alternative 2 thus had a negative response. Reuse again was neutral, since it could be adopted with any alternative. The other alternatives, incorporating centralization to some degree, had positive responses.

The reuse criterion included not only the concept of providing process water for industry, but also of returning renovated wastewater back to the stream system. All systems did this, but Alternatives 3 and 4, which included measures to reclaim water after land application, did it to a higher degree. Thus, they were held to have positive responses as opposed to the neutral entries for Alternatives 1 and 2. Alternative 5, being in fact the embodiment of the basic reuse concept, had a positive response.

All alternatives, save the Decentralized Water Treatment Alternative, would require major institutional change in order to be implemented. The Decentralized Water Alternative could easily be implemented utilizing existing institutions. Because of the significant local efforts which would be required to form and operate new institutions and in comparison with the situation for Alternative 2, their criterion responses were viewed as negative. The response for Alternative 2 was seen as positive.

When each alternative was viewed from the standpoint of its response to all selection criteria, the results were as follows:

Alternative 1 – Centralized Water Treatment

Responded well in general.

Alternative 2 – Decentralized Water Treatment

Questions remained as to the benefits of this system versus one employing centralization. Less than optimal use of technology. Less than optimal contributions to environmental quality. Best institutionally.

Alternative 3 – All Land Treatment

Uncertainties existed concerning cost-effectiveness of the plan and its social effects.

Alternative 4 – Combination Land-Water Treatment

Best overall response.

Alternative 5 – Industrial Reuse

Good response, though some criteria not applicable to concept when viewed as an alternative, rather than an option.

The result of this portion of the screening process was the elimination of the All Land Alternative, as reflected by the dashed line in Figure 19. Also, the Reuse Alternative was reformulated as an option to be added to any alternative.

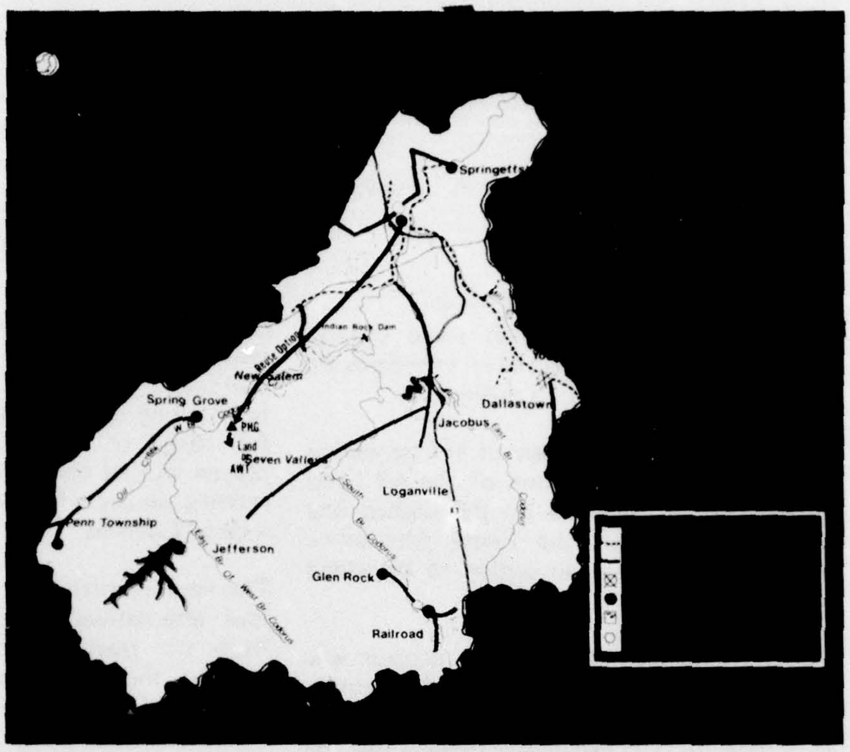
The next step in the planning process was the refinement of the remaining alternatives. Further screening then ensued, as reflected in Figure 19. The evaluation process was the same, with both modified water-oriented processes (maximum decentralization and sub-centralization) being eliminated. The reasoning was basically the same. Based on available data, the Combination Land-Water Treatment Alternative responded best to the selection criteria, particularly in the areas of cost-effectiveness, environmental quality, and technology.

At this time, the planning process conducted by the Policy Committee and Citizens Advisory Committee had gone as far as it could. Within the selection criteria they had developed, reflecting their individual, group, and institutional values, and using available information, they had formulated a plan, the December Plan, which they felt would best meet the study objective of providing a significant improvement in the water quality of the Codorus.

The mission still remained, however, for the study team, using the most current information, to develop the screened-out polar concepts of all water and all land treatment. Also there was a need for a plan which provided for the continuation of present wastewater management trends in the study area. In effect, this plan would yield an answer to the question of "What would happen if none of the plans providing for high level treatment were adopted?" This plan to meet current standards had been present in the plan formulation process, but was screened out along with the other all water alternatives.

Only by developing the Plan to Meet Current Standards, a Basic All Water Plan, and a Basic All Land Plan and then presenting these along with the December Plan, could a full range of technological choice be displayed so that decision makers could make a rational choice which would best provide for a clean Codorus.

The next chapter describes and compares the four alternatives for choice which resulted from the plan formulation process. As a preview, they are shown in Figure 23. They are: The Plan to Meet Current Standards, which evolved from the screened out all water alternative and was based on existing plans; the Basic All Water Plan, coming also from the screened out all water alternative; the Basic All Land Plan, coming from the screened out all land alternative; and the December Plan, a combination land-water treatment plan which was the product of the screening process.



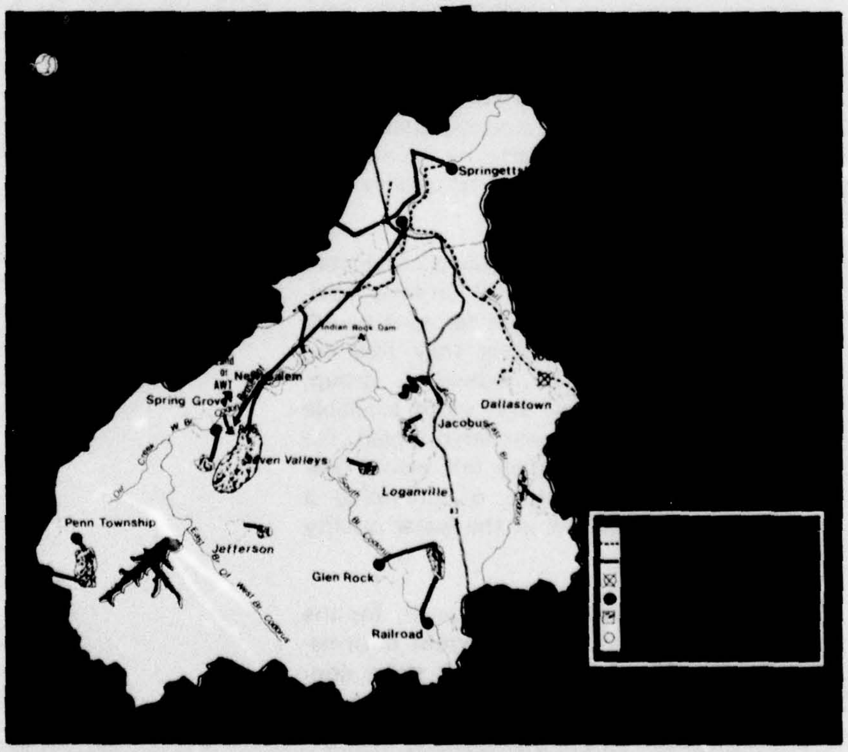
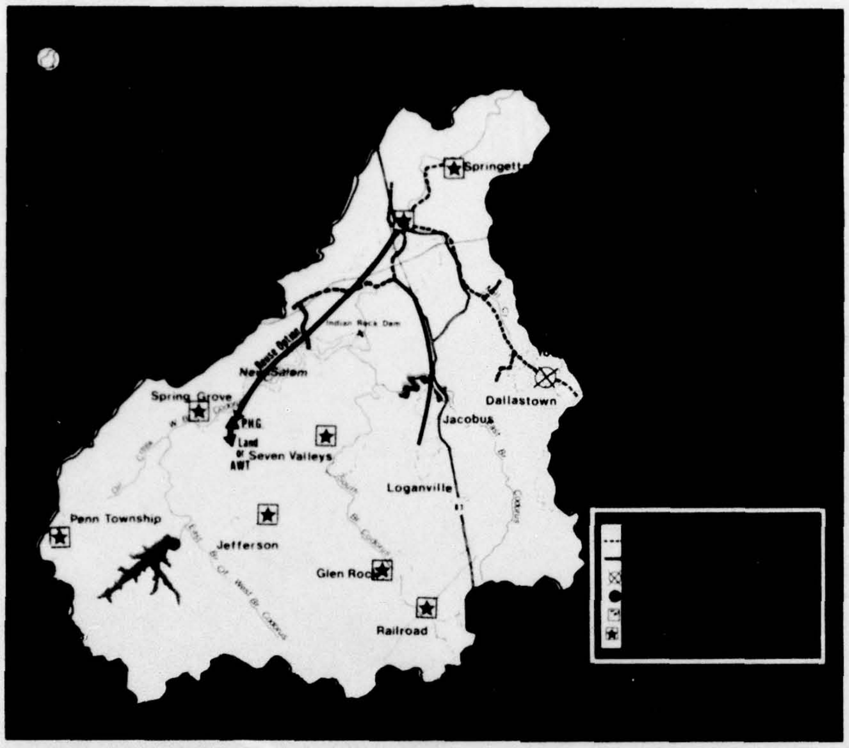


Figure 23. Alternatives For Choice


Springett
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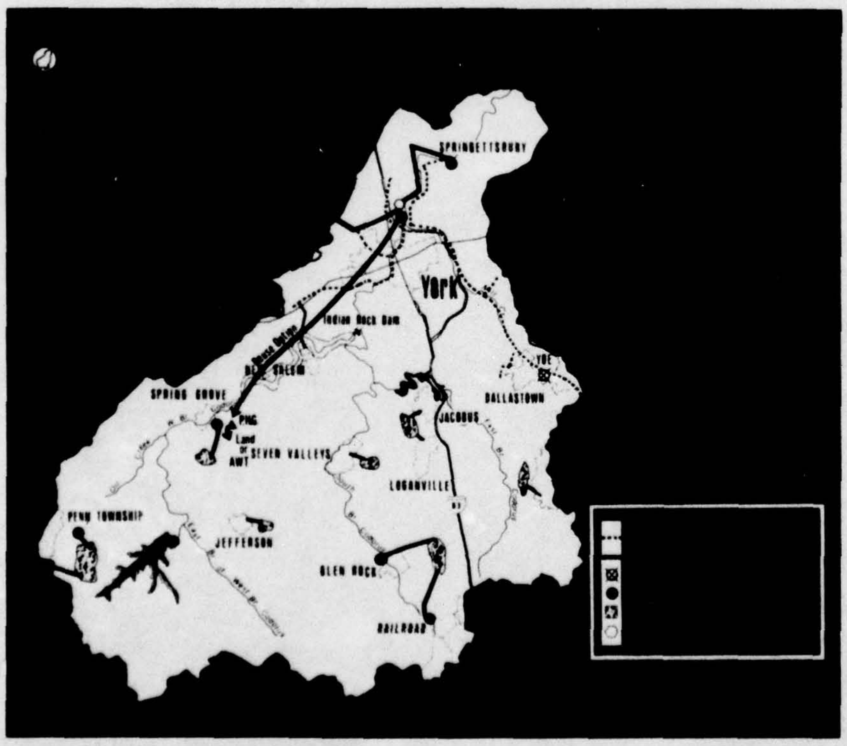
New Salem
Dallastown
Spring Grove
PHG
Jacobus
Land of AWT
Seven Valleys
Loganville
Penn Township
Jefferson
Glen Roc
Railroad


SPRINGETTSBURY
York
Indian Rock Dam
YDE
SPRING GROVE
DALLASTOWN
PHG
JACOBUS
Land of AWT
SEVEN VALLEYS
LOGANVILLE
PENN TOWNSHIP
JEFFERSON
GLEN ROCK
RAILROAD

CHAPTER VI ALTERNATIVES FOR CHOICE

The plan formulation process for the Codorus Creek Wastewater Management Study, as described in Chapter V, produced four Alternatives For Choice, alternatives which are called the Plan To Meet Current Standards, Basic All Water Plan, Basic All Land Plan, and December Plan. Applicable to each of these is an option which provides for the reuse of treated wastewater.

The purpose of this chapter is to analyze in detail each of the Alternatives For Choice. Included for each of these is a description of their component parts and configuration, a presentation of their capital and average annual costs, and an analysis of their responses to the selection criteria. Also included in this chapter is a discussion of the problems associated with, and the plans for, industrial wastewater, sludge management, and stormwater; and a discussion of the plans for meeting the wastewater management needs of the Codorus Creek Basin beyond the year 2000 (Framework for 2020).

All of the Alternatives For Choice are designed to provide service to each population center in the Codorus Creek study area. With the exception of the Basic All Land Plan, all alternatives make maximum use of existing treatment facilities. However, the treatment plants now serving Dover Borough and Red Lion would be abandoned in all cases. Secondary treatment for Dover would be accomplished by the locally proposed Dover Township plant. Raw wastewater from the Red Lion area would be conveyed by a locally proposed interceptor sewer (the Mill Creek Interceptor) to the Springettsbury Township plant.

PLAN TO MEET CURRENT STANDARDS

Description

The Plan to Meet Current Standards is based on a projection of continuation of present trends in the Codorus Creek Basin as reflected in the Commonwealth of Pennsylvania's plan for implementing water quality standards. One of the first major actions taken under this plan was the issuance of orders to the City of York to "upgrade" its existing secondary wastewater treatment plant. This plant is operated by the York City Sewer Authority and is designed to treat 18 million gallons per day (mgd) of municipal and industrial wastewater. This plant, the largest in the study area, serves the City of York, North York and West York Boroughs, and the townships of Spring Garden, Manchester, West Manchester, and York. Because of anticipated system overloading and the water quality problems resulting from the discharge of secondary effluent into Codorus Creek, the Commonwealth of Pennsylvania has ordered the York City Sewer Authority to take the following actions:

1. Expand treatment capacity from 18 mgd to 26 mgd.

2. Install facilities to achieve 80 percent removal of phosphorus.

3. Reduce the BOD concentration in the final effluent to no more than 7 milligrams per liter (mg/l) during the summer months.

4. Increase the dissolved oxygen (DO) content of the effluent to at least 6 mg/l.

As part of plant expansion, the above mentioned orders would require system processes consisting of facilities for phosphorus removal, filtration through sand or graded media to achieve ultimate BOD reduction, and reaeration to increase DO concentration.

Because of the high levels of treatment required by the Commonwealth's standards, it was assumed, for the purposes of developing the Plan to Meet Current Standards, that remaining urban centers in the Codorus Creek study area will be required to provide the same levels of advanced wastewater treatment as those of the City of York. This plan, therefore, includes the following treatment components:

1. Primary and secondary biological treatment facilities.

2. Phosphorus removal facilities (80% removal).

3. Facilities for filtration through sand or graded media.

4. Reaeration facilities.

5. Chlorination facilities.

6. Sludge digestion and disposal facilities.

As shown on Plate 1, the Plan to Meet Current Standards includes the following components:

York Urban Area:
(Year 2000 Design
Flow – 36.0 mgd)

Expansion and upgrading of York City secondary plant

Transmission system carrying untreated wastewater from New Salem, Jacobus, and Loganville to City of York system

Springettsbury Township:
(Year 2000 Design
Flow – 12.5 mgd)

Expansion and upgrading of Springettsbury secondary plant

Dover Township:
(Year 2000 Design
Flow – 2.8 mgd)

Expansion and upgrading of Dover Township secondary plant

Jefferson:
(Year 2000 Design
Flow – 0.04 mgd)

Secondary treatment to replace existing individual on-lot disposal

Seven Valleys:
(Year 2000 Design
Flow – 0.07 mgd)

Secondary treatment to replace existing individual on-lot disposal

Winterstown:
(Year 2000 Design
Flow – 0.03 mgd)

Secondary treatment to replace existing individual on-lot disposal

Hanover:
(Year 2000 Design
Flow – 3.9 mgd)

Expansion and upgrading of Hanover secondary plant

Penn Township:
(Year 2000 Design
Flow – 2.2 mgd)

Expansion and upgrading of Penn Township secondary plant

Spring Grove:
(Year 2000 Design
Flow – 0.3 mgd)

Expansion and upgrading of Spring Grove secondary plant

Glen Rock:
(Year 2000 Design
Flow – 0.5 mgd)

Expansion and upgrading of Glen Rock secondary plant

Shrewsbury-New Freedom
Railroad:
(Year 2000 Design
Flow – 1.9 mgd)

Expansion and upgrading of New Freedom secondary treatment plant

The Dover Township and Hanover plants would discharge to Conewago Creek while the remaining plants would discharge to Codorus Creek or its tributaries.

Discussion

The Plan to Meet Current Standards is designed to represent the continuation of present wastewater management trends in the study area – continuation of system configuration and continuation of treatment requirements. Therefore, this plan provides for a decentralized system,[1] which is consistent with the existing independent system, and requires no increase in treatment performance over that which it is projected would be required under current standards and policies.

The Plan to Meet Current Standards is the least expensive of the Alternatives For Choice available to the study area. It would improve the quality of the region's streams by reducing discharges of BOD, COD, phosphorus, and suspended solids, and by increasing the concentration of DO in the final treated discharges; still, when considering the performance of all the Alternatives For Choice, this plan offers the least improvement in water quality.

All of the other Alternatives For Choice require significant change from the status quo – for example, deviations from present regional configuration or departures from treatment methods presently being used. The Plan to Meet Current Standards is conspicuous in comparison because it does not require change from the status quo. This characteristic would probably make it the easiest to implement since it would have no additional institutional requirements and would require a minimum of expenditures; however, it would also offer the fewest benefits. For instance, it would generate the fewest employment opportunities, remove the fewest water pollutants, only moderately enhance recreational opportunities, provide no opportunities for change in the status quo, fall short of the study's adopted water quality goals, and, therefore, provide no chance for returning Codorus Creek to near its natural state. Other implications of implementing this plan are:

□ Numerous independent treatment plants maximize quality control and system coordination problems

□ A minimum increase in existing levels of treatment

□ As an extension of status quo, offers no significant positive or negative changes to the present social setting

□ Leaves quantity of streamflow unaltered throughout the study area

Costs

Table 7 presents the costs associated with the Plan to Meet Current Standards.

BASIC ALL WATER PLAN

Description

The Basic All Water Plan provides for advanced water process treatment of all municipal wastewater generated in the Codorus Creek Wastewater Management Study Area. It is designed to achieve a Class D level of performance and calls for the construction of three central treatment plants, one to serve the York Urban Area, one to serve the Hanover-Penn Township-Spring Grove Area, and one to serve the Glen Rock-New Freedom Area. These plants would have, by the year 2000, a design capacity of 51.4 mgd, 6.5 mgd, and 2.4 mgd, respectively, and would contain the following treatment processes:

Secondary Biological Treatment By Contact Stabilization

Nitrogen Removal by Nitrification-Denitrification (98% removal)

Phosphorus Removal by Massive Lime Addition (98% removal)

Filtration through a Media Filter

Post Aeration

Chlorination

As shown on Plate 2, the Basic All Water Plan includes the following features:

[1] The plan's only deviation from the decentralized concept is its transmission system carrying raw wastewater from New Salem, Jacobus, and Loganville into the York Urban Area for treatment at existing facilities.

TABLE 7

COST ESTIMATE: PLAN TO MEET CURRENT STANDARDS

(All Costs in $1,000)

Service Area	Construction Costs 1972-1985	Construction Costs 1986-2000	Operation And Maintenance Cost 1972-1985	Operation And Maintenance Cost 1986-2000	Average Annual Cost (50 years)
York Urban Area	7,530	10,581	1,318	1,794	
Springettsbury Township	4,305	-	539	789	
Dover Township	612	877	131	221	
Hanover	1,905	924	267	322	
Penn Township	547	561	170	207	
Spring Grove	169	256	54	56	
Glen Rock	231	458	54	69	
Shrewsbury-New Freedom-Railroad	501	585	143	185	
Jefferson	158	—	13	13	
Seven Valleys	211	—	10	10	
Winterstown	132	—	10	10	
TOTAL PLAN	16,301	14,242	2,709	3,676	4,699

NOTE: Average annual cost is based on an interest rate of 6%, and includes interest, amortization, operation, maintenance, replacement, and salvage value.

York Urban Area:

Expansion of York City secondary plant
Expansion of Springettsbury secondary plant
Expansion of Dover Township secondary plant
Advanced water process treatment plant near the existing York City secondary plant
Transmission systems carrying untreated wastewater from New Salem, Jacobus, Loganville, Seven Valleys, and Jefferson to the York City system
Transmission systems carrying untreated wastewater from Winterstown to the Mill Creek Interceptor which in turn carries wastewater to the Springettsbury secondary plant
Transmission systems carrying treated wastewater from the York, Springettsbury, and Dover secondary plants to the York Urban Area advanced water process treatment plant

Hanover-Penn Township-Spring Grove Area:

Expansion of Hanover secondary plant
Expansion of Penn Township secondary plant
Expansion of Spring Grove secondary plant
Advanced water process treatment plant near the existing Penn Township secondary plant
Transmission systems carrying treated wastewater from the Hanover-Penn Township and Spring Grove secondary plants to the Penn Township advanced wastewater treatment plant

Shrewsbury-Railroad-Glen Rock-New Freedom Area:

Expansion of Glen Rock secondary plant
Expansion of New Freedom secondary plant
Advanced water process treatment plant near the New Freedom secondary plant
Transmission systems carrying treated wastewater from the Glen Rock and New Freedom secondary plants to the advanced wastewater treatment plant

Although the Basic All Water Plan generally meets the water quality goals established by the Policy Committee, it does not provide for the removal of refractory organics as does the Basic All Land Plan. Although they presently are not a serious problem, the future increases in wastewater volume will result in an increasing discharge of the persistant refractory organics. If they are not

removed, refractory organics could cause real water quality problems in the future. Consequently, a Modified All Water Plan has been developed – a plan which provides for the removal of refractory organics by the addition of the Carbon Adsorption process to each of the three wastewater treatment plants included in the Basic All Water Plan.

Discussion

The Basic All Water Plan offers a departure from the study area's present decentralized treatment system. It consolidates the wastewater from all of the service areas and provides advanced biological water process treatment at three plants. By so doing, it localizes all municipal and industrial wastewater discharges at only three locations. Thus, separate discharges at Dover, into a Conewago tributary, and York and Springettsbury, into Codorus Creek, are replaced by one at York into Codorus Creek; discharges at Hanover, into another Conewago tributary, Penn Township into Oil Creek, and Spring Grove into the West Branch, are replaced by one at Penn Township into Oil Creek; discharges at Glen Rock and New Freedom into the South Branch, are replaced by one at New Freedom at the South Branch. All three of these discharges will be made only after treatment which will remove almost all BOD, COD,[2] suspended solids, phosphorus, and nitrogen, and will increase the effluent concentration of DO. The Basic All Water Plan is designed to achieve both centralization and high treatment performance without abandoning any of the area's existing treatment plants. All of the existing plants would be expanded when required and their effluents would be piped to the proposed advanced water process plants. Of course, this will result in slight streamflow decreases in reaches of Conewago Creek which are below the abandoned upstream sewage outfalls at Hanover and Dover, but, because of the reduction in the number of discharges, this plan should be capable of achieving a level of control unattainable in a more decentralized water process system.

[2]Highest level of performance will be achieved only with the modified plan, which includes carbon adsorption.

Because it is centralized, the Basic All Water Plan presents an institutional problem. Since it integrates the treatment facilities of several corporate entities, it will probably require the formation of an inter-community institution such as a county wastewater management authority before it can be implemented.

The Basic All Water Plan has the highest average annual cost of any of the Alternatives For Choice. However, it provides significant increases in treatment and centralization over the Plan to Meet Current Standards, without physically disrupting the present system. Moreover, the Modified All Water Plan, which includes the carbon adsorption process, provides a level of treatment comparable to the Basic All Land Plan, without the socially disruptive effects of acquiring significant land areas.

By satisfying the study's adopted water quality goals, the Basic All Water Plan would provide a dramatic improvement in the quality of Codorus Creek consistent with other plans for change already being discussed at the local level, such as the plan for developing downtown York which uses Codorus Creek as a focal point and features sidewalk cafes, shops, and boutiques. Such a plan seems unlikely unless it is implemented in a region served by the most advanced wastewater technology.

It must be remembered, however, that advanced water process treatment technology has never been proven in wastewater plants comparable in size to that required for the Codorus Creek study area. To date, the only significant experience with this process has been in pilot and small scale units.

Other impacts on the study area which may result from implementation of the Basic All Water Plan are:

- ☐ Creation of new suitable habitat along transmission pipe rights-of-way may increase the quantity of small game
- ☐ Requires no completely new plant sites, only expansion of existing ones

TABLE 8

COST ESTIMATE: BASIC AND MODIFIED ALL WATER PLANS

(All Costs in $1,000)

Service Area	Construction Costs		Operation And Maintenance Cost		Average Annual Cost (50 years)
	1972-1985	1986-2000	1972-1985	1986-2000	
York Urban Area	35,521	21,815	2,793	3,951	
Hanover-Penn Township-Spring Grove	10,500	1,716	704	841	
Glen Rock-Shrewsbury-New Freedom-Railroad	5,139	989	330	424	
TOTAL – BASIC ALL WATER PLAN	51,160	24,520	3,827	5,216	8,961
TOTAL – BASIC ALL WATER PLAN	51,160	24,520	3,827	5,216	8,961
Additional Cost, Carbon Adsorption	17,318	6,336	952	1,327	2,674
TOTAL – MODIFIED ALL WATER PLAN	68,478	30,856	4,779	6,543	11,635

NOTE: Average annual cost is based on an interest rate of 6%, and include interest, amortization, operation, maintenance, replacement, and salvage value.

☐ Transmission facilities to regional advanced treatment plants will cause initial disruption to landscape

☐ Preservation of open space along transmission lines could be accomplished to favor the visual diversity of the landscape

☐ Provides local employment opportunities during both the construction and operation phases

☐ Although it causes slight streamflow decrease in the Conewago Basin by diverting Hanover and Dover wastewater, it achieves centralization without decreasing streamflow at any point in the Codorus Creek Basin

☐ Should attract industry by making the region a pleasant place to live and work

Costs

The cost estimates for the Basic and Modified All Water Plans are summarized in Table 8.

BASIC ALL LAND PLAN

Description

The Basic All Land Plan provides for treatment of all municipal wastewater generated in the study area by land application methods. It is designed to achieve a Class F level of performance incorporating an optimum degree of centralization consistent with land availability and costs of transmission. A typical system would include the following processes:

Contact stabilization or aerated lagoon secondary treatment followed by clarification

Winter storage of secondary effluent

Chlorination

Irrigation on land at a rate of two inches per week for about eight months of the year

Multi-processing by the "living filter" of the soil – nutrients taken up by plants and soil; filtration of suspended solids; heavy

metals and residual refractory organics adsorbed by soil; bacteria, pathogens, and viruses removed by filtration/adsorption

Irrigated water reclaimed, after treatment, using wells

Post Aeration of reclaimed water

Discharge of treated effluent to nearby streams to increase low flows

As shown in Plate 3, the plan includes the following components:

York Urban Area:
(Year 2000 Design
Flow – 50.8 mgd)

- Transmission facilities carrying untreated wastewater from Springettsbury, Dover, and New Salem to York; and then from York to an aerated lagoon system several miles southwest of York
- Aerated lagoon system providing secondary *treatment* for wastewater from the York, Springettsbury, Dover, and New Salem service areas
- Two storage lakes
- Land disposal facilities consisting of distribution piping and pumping, irrigation machines, and drainage wells
- Land totaling approximately 13,000 acres by the year 2000

Hanover-Penn
Township Area:
(Year 2000 Design
Flow – 6.1 mgd)

- Expansion of Hanover secondary plant
- Expansion of Penn Township secondary plant
- Transmission facilities carrying treated wastewater from the Hanover and Penn Township secondary plants to storage facilities
- Two storage lakes
- Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
- Land totaling approximately 2,400 acres by the year 2000

Shrewsbury-New
Freedom-Railroad-
Glen Rock Area:
(Year 2000 Design
Flow – 2.4 mgd)

- Expansion of New Freedom secondary plant
- Expansion of Glen Rock secondary plant
- Transmission facilities carrying treated wastewater from the New Freedom and Glen Rock secondary plants to storage lake
- Storage lake
- Land disposal system consisting of distribution piping and pumping, irrigation machines, and drainage wells
- Land totaling approximately 1,100 acres by the year 2000

Spring Grove
Service Area:
(Year 2000 Design
Flow – 0.3 mgd)

- Expansion of Spring Grove secondary plant
- Transmission facilities carrying treated wastewater from Spring Grove secondary plant to storage facilities
- Storage lake
- Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
- Land totaling approximately 120 acres by the year 2000

Jacobus-Loganville
Area:
(Year 2000 Design
Flow – 0.41 mgd)

- Transmission facilities carrying untreated wastewater from Jacobus and Loganville to aerated treatment lagoon southwest of Jacobus
- Aerated lagoon providing secondary treatment for combined Jacobus-Loganville wastewater
- Storage lake
- Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
- Land totaling approximately 180 acres by the year 2000

Seven Valleys
Service Area:
(Year 2000 Design
Flow – 0.07 mgd)

Transmission facilities carrying untreated wastewater from Seven Valleys to aerated treatment lagoon
Aerated lagoon providing secondary treatment
Storage lake
Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
Land totaling about 40 acres by the year 2000

Jefferson Service
Area:
(Year 2000 Design
Flow – 0.04 mgd)

Transmission facilities carrying untreated wastewater from Jefferson to aerated treatment lagoon
Aerated lagoon providing secondary treatment
Storage lake
Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
Land totaling approximately 30 acres by the year 2000

Winterstown Service
Area:
(Year 2000 Design
Flow – 0.03 mgd)

Transmission facilities carrying untreated wastewater from Winterstown to aerated treatment lagoon
Aerated lagoon providing secondary treatment
Storage lake
Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
Land totaling about 30 acres by the year 2000

During the public participation program for the Codorus Creek Wastewater Management Study, it was found that the people of the Codorus Creek Basin were generally unfamiliar with the land application process of advanced wastewater treatment. This unfamiliarity manifested itself in uncertainties relative to the social implications of the process. This was one of the main issues at Citizen Advisory Committee Meetings and Public Meetings. Questions were asked such as, "Will the storage lakes produce obnoxious odors?," "Will the wind cause spray to drift into residential areas and, thereby, cause a threat to public health?," "Can one live in close proximity to the spray irrigation field?," "Will water supply wells be contaminated?" Also expressed was a strong desire to retain and incorporate into the system as many as possible of the existing wastewater treatment facilities, regardless of the economic consequences of this. Consequently, a Modified All Land Plan was developed. This plan incorporated safeguards over and above those which are necessary to protect the public health and welfare – safeguards designed to respond to the uncertainties of the people. Included in these are the purchases of tracts of land to act as additional buffer zones, the purchases of all homes in close proximity to the irrigation fields, and provisions for maximum utilization of existing treatment plants.

Discussion

The Basic All Land Plan combines the present decentralized character of the upper Codorus Basin with a centralized system for the York Urban Area. It achieves a level of treatment performance consistent with the study's water quality goals by applying all of the area's wastewater[3] to the land. The systems proposed in the Basic All Land Plan would remove from the wastewater nearly all BOD, COD, suspended solids, phosphorus, and nitrogen, and would increase the downstream dissolved oxygen concentrations. Since all irrigated wastewater would be recovered from the ground after treatment, and conveyed to the nearest stream, and since all of the receiving streams are in the headwaters, there would be locally meas-

[3]The industrial wastewater generated by the P. H. Glatfelter Company is handled separately. See page

urable increases in streamflow, particularly in Codorus Creek as it flows through York.

The average annual cost of the Basic All Land Plan is less than any of the other Alternatives For Choice of comparable performance, that is, ones which satisfy the study's water quality goals. The difference in cost between the Basic and Modified All Land Plan represents the price which must be paid to realize any benefits which may be associated with retaining the activated sludge process for secondary treatment and relocating people from areas adjacent to the land disposal sites.

The Basic All Land Plan requires significant areas of land for treatment lagoons, storage ponds, and especially irrigation. Satisfying this land requirement has the potential for producing some negative effects, such as reducing the local tax base and altering residential patterns, especially if the land is purchased. These effects could be reduced if some method other than purchase was used to satisfy the land requirement (other methods are discussed in Chapter VIII). Even if the land is purchased, however, the use of this quantity of land for wastewater management offers some positive benefits. The most obvious is that large acreages of land would remain in a semi-natural state. Also, crop production would increase because of the assurance of irrigation water and the addition of wastewater nutrients to the land which would act as soil conditioners and food for crops. In addition, the possibility exists to devise components of the Basic All Land Plan so that they complement other regional programs. For instance, the land acquired for buffer zones could be used to simultaneously satisfy some or all of the land requirements of a proposed solid waste management plan which is already being discussed at the local level.

The land requirements developed for the Basic All Land Plan are based on a wastewater application rate of two inches per week for eight months per year. The actual land required could be reduced by lengthening the irrigation season or by increasing the application rate (present Commonwealth of Pennsylvania standards allow a maximum application of two inches per week).

By satisfying the study's adopted water quality goals, the Basic All Land Plan would provide a dramatic improvement in the quality of Codorus Creek consistent with other plans for change already being discussed at the local level, such as the plan for developing downtown York using Codorus Creek as a focal point. This development plan would be further enhanced by an increase in streamflow through York which would result from implementing the Basic All Land Plan.

Other results of implementing the Basic All Land Plan are listed below:

☐ Creation of new suitable habitat along transmission pipe rights-of-way may increase quantity of small game

☐ Transmission facilities from service areas to land treatment sites will cause initial disruption to landscape

☐ Preservation of open space along transmission lines could be accomplished to favor the visual diversity of the landscape

☐ A major disturbance will occur in the terrestrial environment at each storage pond

☐ Land application will achieve a treatment performance with some parameters, such as viruses and phosphorus, unattainable with any other technology

☐ Within an irrigation area there will be an increase in the number of insects, especially mosquitoes

☐ Provides local employment opportunities during both the construction and operations phases

☐ Buffer zones provide land for sludge disposal

☐ Abandoned treatment plants could be used for storage or treatment of urban stormwater

TABLE 9

COST ESTIMATE: BASIC AND MODIFIED ALL LAND PLANS

(All Costs in $1,000)

Service Area	Construction Costs		Operation And Maintenance Costs		Average Annual Cost (50 years)
	1972-1985	1986-2000	1972-1985	1986-2000	
York Urban Area	60,723	6,027	1,557	2,068	
Hanover-Penn Township	10,427	1,452	422	531	
Spring Grove	714	264	48	50	
Shrewsbury-New Freedom-Railroad-Glen Rock	5,478	989	167	228	
Jacobus-Loganville	989	-	13	16	
Seven Valleys	292	-	9	10	
Jefferson	250	-	9	9	
Winterstown	228	-	8	8	
TOTAL – BASIC ALL LAND PLAN	79,101	8,732	2,233	2,920	8,044
TOTAL – BASIC ALL LAND PLAN	79,101	8,732	2,233	2,920	8,044
Additional Costs, Activated Sludge, Buffer Zones	8,107	10,028	710	1,036	1,638
TOTAL – MODIFIED ALL LAND PLAN	87,208	18,760	2,943	3,956	9,682

NOTE: Average annual cost is based on an interest rate of 6%, and includes interest, amortization, operation, maintenance, replacement, and salvage value.

☐ Imaginative design and location of facilities can develop a large potential for multiple use

☐ Achieves a dramatically high level of treatment consistent with a healthy ecosystem and full recreational stream use

☐ Consistent with plans for change already being discussed at the local level such as the previously described plan for developing downtown York

Costs

The cost estimates for the Basic and Modified All Land Plans are summarized in Table 9.

DECEMBER PLAN

Description

The December Plan resulted from the plan formulation process conducted by the Policy Committee. It provides for the achievement of Class D performance through advanced water process treatment of the wastes generated in the York Urban Area and Class F performance through land application treatment of the wastes generated in the remaining urbanized portions of the study area.

The water process treatment plant for the York Urban Area would contain the following treatment processes:

Secondary Biological Treatment
Nitrogen Removal by Nitrification-Denitrification (98% removal)
Phosphorus Removal by Massive Lime Addition (98% removal)
Filtration through a Media Filter
Post Aeration
Chlorination

A typical land application treatment system would contain the following processes and units:

Secondary Biological Treatment
Winter storage of secondary effluent
Chlorination
Irrigation on land at the rate of two inches per week for about eight months of the year
Multi-processing by the "living filter" of the soil-nutrients taken up by plants and soil; filtration of suspended solids; heavy metals and residual refractory organics adsorbed by soil; bacteria, pathogen, and virus removal by filtration/adsorption
Irrigated water reclaimed after treatment, using wells
Post aeration of reclaimed water
Discharge of treated effluent to nearby streams

As shown on Plate 4, the December Plan includes the following components:

York Urban Area:
(Year 2000 Design
Flow – 50.8 mgd)

Expansion of the York City secondary plant
Expansion of the Springettsbury secondary plant
Expansion of the Dover Township secondary plant
Advanced water process treatment plant near the York City secondary plant
Transmission system carrying untreated wastewater from New Salem to the York secondary plant
Transmission system carrying treated wastewater from the York, Springettsbury, and Dover secondary plants to the York advanced water process treatment plant

Hanover-Penn
Township Area:
(Year 2000 Design
Flow – 6.1 mgd)

Expansion of Hanover secondary plant
Expansion of Penn Township secondary plant
Transmission facilities carrying treated wastewater from the Hanover and Penn Township secondary plants to storage facilities
Two storage lakes
Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
Land totaling approximately 2,400 acres by the year 2000

Shrewsbury-New
Freedom-Railroad-
Glen Rock Area:
(Year 2000 Design
Flow – 2.4 mgd)

Expansion of New Freedom secondary plant
Expansion of Glen Rock secondary plant
Transmission facilities carrying treated wastewater from the New Freedom and Glen Rock secondary plants to storage lakes
Storage lake
Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
Land totaling approximately 1,100 acres by the year 2000

Spring Grove
Service Area:
(Year 2000 Design
Flow – 0.3 mgd)

Expansion of Spring Grove secondary plant
Transmission facilities carrying treated wastewater from Spring Grove secondary plant to storage facilities
Storage lake
Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
Land totaling approximately 120 acres by the year 2000

Jacobus-Loganville
Area:
(Year 2000 Design
Flow – 0.41 mgd)

Transmission facilities carrying untreated wastewater from Jacobus and Loganville to a secondary biological treatment plant for combined Jacobus-Loganville wastewater
Storage lake
Land disposal system consisting of distribution piping, pumps, irrigation machines,

and drainage wells
Land totaling approximately 180 acres by the year 2000

Seven Valleys
Service Area:
(Year 2000 Design
Flow – 0.07 mgd)

Transmission facilities carrying untreated wastewater from Seven Valleys to a secondary biological treatment plant
Secondary biological treatment plant
Storage lake
Land disposal system consisting of distribution piping, pumps, irrigation machines, and drainage wells
Land totaling about 40 acres by the year 2000

Jefferson Service
Area:
(Year 2000 Design
Flow – 0.04 mgd)

Transmission facilities carrying untreated wastewater from Jefferson to a secondary biological treatment plant
Secondary biological treatment plant
Storage lake
Land disposal system consisting of distribution piping pumps, irrigation machines, and drainage wells
Land totaling approximately 30 acres by the year 2000

Winterstown Service
Area:
(Year 2000 Design
Flow – 0.03 mgd)

Transmission facilities carrying untreated wastewater from Winterstown to a secondary biological treatment plant
Secondary biological treatment plant
Storage lake
Land disposal system consisting of distribution piping and pumps, irrigation machines, and drainage wells
Land totaling approximately 30 acres by the year 2000

Discussion

The December Plan employs both of the Codorus Creek Wastewater Management Study's two basic concepts: advanced water process treatment and land application of partially treated wastewater. It was selected at a point in time (December 1971) during the planning process by the Policy Committee and the Citizens Advisory Committee based on the information then available to them. It combines centralization in the populous northern basin with decentralization in the southern basin. This feature balances the objective of achieving economies of scale through centralization with the desire to make full use of the considerable existing investments in wastewater treatment facilities in the basin.

The December Plan allows for smooth transition from the present treatment systems to the high level treatment necessary to attain the study's adopted water quality goals. Both the advanced water process component in the York Urban Area and the land application system in the upper basin build upon the present system. The December Plan would accomplish almost complete removal of BOD, suspended solids, phosphorus, nitrogen, and in the case of the land process units, COD, and would increase instream dissolved oxygen concentrations.

The average annual cost of the December Plan is less than that of the Basic All Water Plan, but more than the cost of the Basic All Land Plan. It combines features of both the Basic Plans without committing the entire region to either of the two basic treatment technologies. Its water process components are similar to those of the Basic All Water Plan while its land process components are similar to those of the Modified All Land Plan.

The implementation of the December Plan would have the following results:

□ Creation of new suitable habitat along transmission pipe rights-of-way may increase quantity of small game

- Transmission lines from service areas in the upper basin to land treatment sites will cause initial disruption to landscape

- Preservation of open space along transmission lines could be accomplished to favor the visual diversity of the landscape

- A major disturbance will occur in the terrestrial environment at each storage pond

- In the upper basin land application will achieve a treatment performance with some parameters, such as viruses and phosphorus, unattainable with any other technology

- Within an irrigation area there will be an increase in the number of insects, especially mosquitoes

- No existing treatment facilities would be abandoned

- Local employment opportunities would be provided during both the construction and operations phases

- Where land process treatment is employed, considerable acreage of land will remain in a semi-natural state

- Achieves a dramatically high level of treatment consistent with a healthy ecosystem and full recreational stream use

- Partially utilizes wastewater nutrients in crop production

- Offers opportunity for the regional public to observe the performance of the land application of wastewater on a small scale

- Consistent with plans for change already being discussed at the local level such as the previously described plan for developing downtown York

Costs

The cost estimate for the December Plan is summarized in Table 10.

THE REUSE OPTION

Description

If water can be used more than once before leaving a basin system, the resource is conserved and becomes more productive. Reuse of treated wastewater seeks to effect this conservation and reap the increased productivity of water generated by recycling.

The concept for reuse in the Codorus Creek Basin is straightforward. After secondary treatment, the wastewater would be transmitted to a location where it would be reused, then provided advanced waste treatment. The method already exists on a small scale in the study area, a prime example of this being the P. H. Glatfelter Company which recycles a portion of its process water. This study has found that, on a large scale, reuse is extremely attractive, especially for industrial process water. The Codorus Creek study area, however, contains only one large user of industrial process water, the P. H. Glatfelter Company at Spring Grove. All industry in the study area generates a total of 29.1 mgd of wastewater. Of this, P. H. Glatfelter produces 17.2 mgd or 59 percent of the total. It is obvious that P. H. Glatfelter Company is the key to the success of large scale industrial reuse of wastewater.

Potential for reuse in the basin is predominantly associated with the York Urban Area treatment system. Other components of the regional systems are not affected. Instead of providing advanced treatment for all the wastewater generated in the York Urban Area, a portion could be transmitted to the P. H. Glatfelter Company for use as process water, thereby releasing its present water supply sources for other uses. The wastewater, after reuse, would be treated by either advanced water process or land application techniques, a choice P. H. Glatfelter Company has to make under any circumstances.

As shown on Plates 1 through 4, the Reuse Option is applicable to any one of the

TABLE 10
COST ESTIMATE: DECEMBER PLAN
(All Costs in $1,000)

Service Area	Construction Costs 1972-1985	Construction Costs 1986-2000	Operation And Maintenance Costs 1972-1985	Operation And Maintenance Costs 1986-2000	Average Annual Cost (50 years)
York Urban Area	33,414	21,815	2,775	3,930	
Hanover-Penn Township	11,692	1,452	422	531	
Spring Grove	714	264	48	50	
Shrewsbury-New Freedom-Railroad-Glen Rock	5,786	989	167	229	
Jacobus-Loganville	1,191		13	16	
Seven Valleys	329	-	9	10	
Jefferson	270	-	9	9	
Winterstown	250	-	8	8	
TOTAL DECEMBER PLAN	53,646	24,520	3,451	4,783	8,567

NOTE: Average annual cost is based on an interest rate of 6%, and includes interest, amortization, operation, maintenance, replacement, and salvage value.

Alternatives For Choice. Each of these alternatives, however, would require slight modification to accomplish this. These are:

Plan to Meet Current Standards:

Construct pumping station and pipeline to transmit secondary treated wastewater from York plant to P. H. Glatfelter Company

Basic All Water Plan:

Eliminate advanced water process treatment plant at York and provide smaller advanced water process treatment plant at Springettsbury Township

Construct pipeline from York secondary plant to advanced treatment plant at Springettsbury

Construct pumping station and pipeline to transmit secondary treated wastes from York plant to P. H. Glatfelter Company

Basic All Land Plan:

Provide a pipeline to transmit secondary treated wastewater to P. H. Glatfelter from the proposed pipeline connecting York with the land application areas

December Plan:

Eliminate advanced water process treatment plant at York and provide smaller advanced water process treatment plant at Springettsbury Township

Construct pipeline from York secondary plant to advanced water process treatment plant at Springettsbury

Construct pipeline from York secondary plant to transmit secondary treated effluent from York to P. H. Glatfelter

All other component parts of the Alternatives For Choice would be unaffected. No major modifications to the P. H. Glatfelter system would be required other than expansion which are independent of wastewater reuse.

Discussion

The reuse of wastewater in industrial processes is a significant step toward the achievement of totally integrated management of the water resources of the Codorus

TABLE 11

COST ESTIMATE: REUSE OPTION

(All Costs in $1,000)

Alternative For Choice	Construction Cost		Average Annual Cost	
	Without Reuse	With Reuse	Without Reuse	With Reuse
Plan To Meet Current Standards	46,436	52,625	8,318	8,298
Basic All Water Plan	91,573	89,832	12,580	11,095
Basic All Land Plan	103,726	95,757	11,644	10,033
December Plan	94,059	92,319	12,186	10,611

NOTE: 1. Average annual cost is based on an interest rate of 6%, and includes interest, amortization, operation, maintenance, replacement, and salvage value.
2. All costs included P. H. Glatfelter costs for wastewater management and water supply pre-treatment.

Creek Basin. Not only is it the least expensive means for achieving a meaningful improvement in the quality of the waters of Codorus Creek, but it provides for a rational method of conserving its increasingly precious waters. And most important, it accomplishes this without necessitating the construction of any wastewater treatment facilities in addition to those already required. This is especially meaningful if the Basin All Land Plan is implemented and P. H. Glatfelter chooses to also apply his wastes to the land, as the institution of the Reuse Option would not require the purchase of any additional land. In other words, the land area required to treat the wastewater from the York Urban Area without reuse is the same as that required to treat the wastewaters from both the York Urban Area and the P. H. Glatfelter Company with reuse.

The Codorus Creek Basin is water short and is in vital need of new opportunities for source development as well as opportunities for the institution of water conservation measures. The Reuse Option would contribute to these in three ways. It would conserve water by reusing renovated wastewater; it would add to the low flow of Codorus Creek above and through York by conveying wastewater which would normally be discharged into the stream below York; and it would free P. H. Glatfelter's present water supply sources for other uses. Lake Marburg, the focus of the Codorus Creek State Park, is one of these sources. It was constructed for the sole purpose of furnishing process water to the P. H. Glatfelter Company. If the Reuse Option were implemented, this lake could be fully utilized for recreation or could become an additional source of water supply for basin communities.

The problems associated with implementing the Reuse Option appear to be predominantly institutional ones. For instance, cost sharing arrangements must be formulated to equitably distribute the costs of constructing transmission and jointly used treatment facilities. Also, it must be ascertained who will operate and maintain the various components of the system and how the cost to do this will be distributed. The key to resolving these problems is the consummation of a formal agreement which is equitable to all concerned parties. Not until this is done will reuse of wastewater become a reality in the Codorus Creek Basin.

Cost Estimate

Table 11 shows the estimated cost of the Reuse Option for each of the four Alternatives For Choice. Also shown on the table is the estimated cost of each of the alternatives when the price of a separate wastewater treatment system for P. H. Glatfelter is added to them. These estimates are based on the assumptions that P. H. Glatfelter would use water process treatment under the Basic All Water Plan, the December Plan, the Plan

for Meeting Current Standards, and if reuse were not chosen. If the Basic All Land Plan is implemented, it is assumed that P. H. Glatfelter will treat its wastewater by land application methods.

COMPARING THE ALTERNATIVES FOR CHOICE

Figure 24 presents for comparison the total capital costs and average annual costs of the Alternatives For Choice without the Reuse Option. Costs comparisons considering the Reuse Option were presented in Table 11.

Table 12 compares the treatment performance which would be achieved by the Plan to Meet Current Standards and treatment components of the Basic All Water, Basic All Land, and December Plans.

Table 13 is a matrix which summarizes the responses of the Alternatives For Choice to the nine selection criteria. The following is a discussion of the costs, performance, and impacts of the Alternatives For Choice as reflected in the matrix.

National Economic Development (Cost-Effectiveness)

Positive responses are indicated for the Plan to Meet Current Standards, the Basic All Land Plan, and the Reuse Option. The Plan

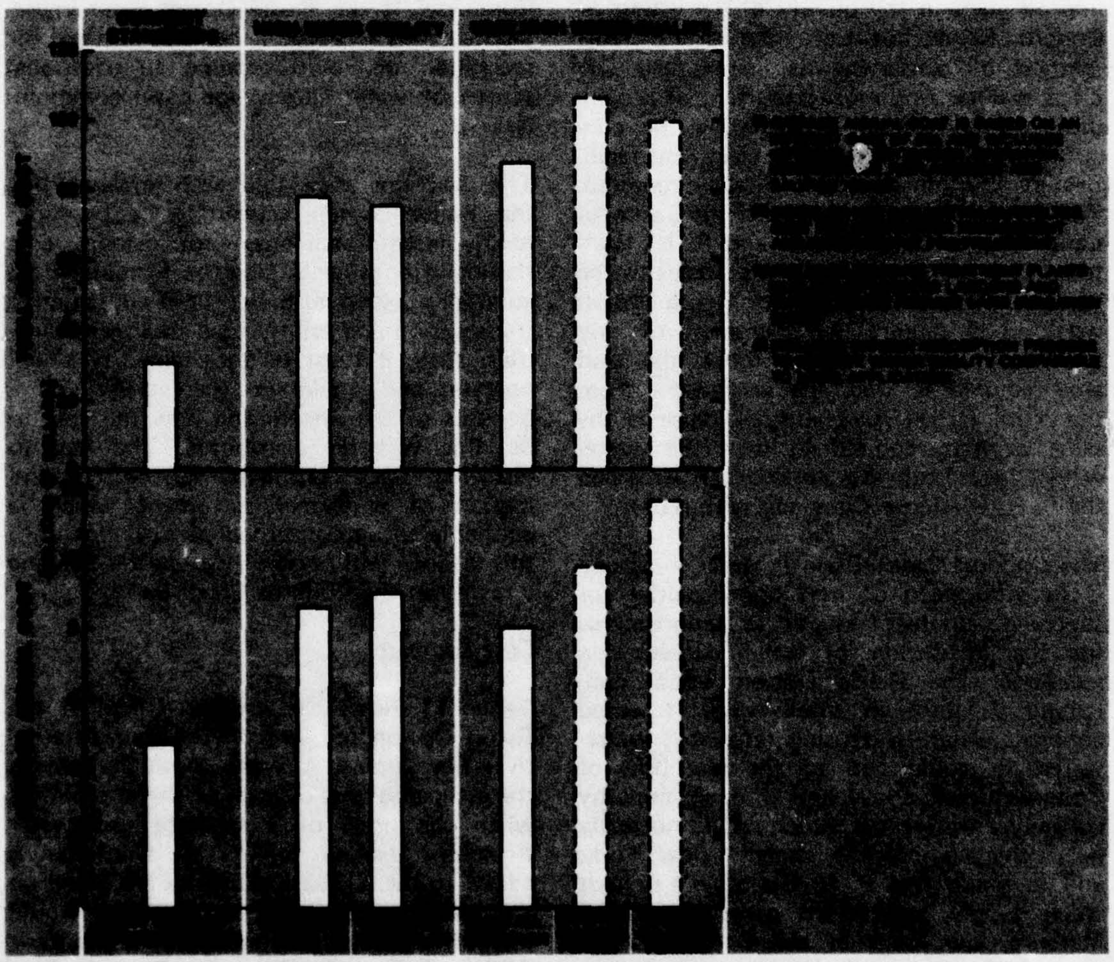


Figure 24. Cost – Performance Comparison of Alternatives for Choice[1,2]

TABLE 12

TREATMENT PERFORMANCE

(Expressed As Effluent Concentrations In Milligrams Per Liter)

	Advanced Water Process Treatment	Advanced Land Treatment System	Plan To Meet Current Standards
COD	30[1]	5	45
BOD	4	3	7
SS	3	0	3
TDS	350	400	400
P	0.2	0.05	2
N	2	2	20

1Significantly lower if carbon absorption is added, as in Modified All Water Plan.

to Meet Current Standards is the least expensive plan available to the study area, but it does not meet the study's adopted water quality goals. The Basic All Land Plan is the least expensive one which does achieve the study's adopted water quality goals, i.e., it would achieve a quality of water which would provide a basis for the restoration of natural environmental values while simultaneously serving the economic and social needs of the people. The study has shown that the Reuse Option has cost advantages if the option is exercised with any of the other Alternatives For Choice. The Basic All Water Plan is the most expensive of the alternatives.

Regional Development

In general, any multimillion dollar construction program would have considerable impacts on the economy of the Codorus Creek Basin. Large amounts of money would be pumped into the study area via the purchase of land, local materials and labor, and the increased demand for local goods and services generated by immigrating construction and operating personnel. A minimum of such effects would be produced by the Plan to Meet Current Standards since it would require the least amount of funds. In addition, the Reuse Option enhances the availabiltiy of a major production factor (water) to local industry.

Beyond the construction stage, the Plan to Meet Current Standards has the least potential for stimulating regional development. Although the other three Alternatives For Choice have approximately the same potential for increasing income, increasing employment, improving the economic base, and improving the educational, cultural, and recreation opportunities, the addition of the Reuse Option makes them particularly attractive. It not only would make possible increasing opportunities within the P. H. Glatfelter Company, but would contribute toward solving the water short problems of the area by recycling wastewater and freeing Lake Marburg for other uses. This, in itself, should act as a stimulus for expansion of the economic base, consequently making the Codorus Creek Basin a more attractive place to live.

Environmental Quality

All of the Alternatives For Choice would act to enhance the study area environment by improving the condition of one of the region's natural resources. The Plan to Meet Current Standards, however, would offer no additional improvement over an extension of the status quo. The Reuse Option has a synergistic effect on environmental values, in that it features recycling of the regional water supply in such a way as to accommodate both natural resource conservation and economic growth.

Social Well-Being

The Plan to Meet Current Standards, as a technological and institutional extension of the status quo, should have no effects on the social setting of the study area. The Basic All Water, Basic All Land, and December Plans would each offer opportunities for positive change by dramatically improving the quality of the region's streams. This improvement in water quality would make the study area more attractive as a place to live and work, and would enhance locally initiated improvement programs such as the previously discussed plan for redeveloping downtown York with Codorus Creek as a focal point. In addition, the Reuse Option

TABLE 13
ALTERNATIVES FOR CHOICE
RESPONSES TO SELECTION CRITERIA

Selection Criteria \ Alternatives For Choice	Plan To Meet Current Standards	Basic All Water Plan	Basic All Land Plan	December Plan	Reuse Option
National Economic Development (Cost Effectiveness)	+	−	+	−	+
Regional Development	N	+	+	+	+
Environmental Quality	N	+	+	+	+
Social Well-Being	N	+	+	+	+
Technology	N	+	+	+	+
Water Quality Goals	N	+	+	+	+
Centralization	N	+	+	+	N
Reuse	N	+	+	+	+
Institutional Arrangements	+	−	−	−	−

NOTE: The entries in this matrix reflect system response relative to existing conditions.

\+ Positive response
− Negative response
N No response

offers the opportunity of making higher and better recreational (and perhaps other) use of Lake Marburg.

Technology

All of the Alternatives For Choice, except the Plan to Meet Current Standards, involve the employment of presently available technology in wastewater management to a greater extent than is presently contemplated at the local level.

Water Quality Goals

The Basic All Water, Basic All Land, and December Plans are all designed to achieve the study's adopted water quality goals; the Plan to Meet Current Standards is not. The Reuse Option is not, per se, a water quality measure, but is designed as a conservation add-on to any of the other Alternatives For Choice.

Centralization

The Basic All Water, Basic All Land, and December Plans each include some degree of centralization; the Reuse Option has a neutral response here since it can be added to any of the other Alternatives For Choice, even the decentralized Plan to Meet Current Standards.

Reuse

Reuse of treated wastewater can be accomplished under any of the four Alternatives For Choice. By applying the Reuse Option as part of the Basic All Land Plan, a maximum in reuse benefits can be realized, since treated wastewater would be provided not only for industry but for agricultural purposes as well.

Institutional Arrangements

Except for the Plan to Meet Current Standards, all of the Alternatives For Choice require some new intergovernmental cooperation or institutional arrangements to implement and manage.

INDUSTRIAL WASTEWATER MANAGEMENT

The projected wastewater service areas for the Codorus Creek Wastewater Management Study have been described in other portions of this report. Located within these service areas are the majority of the major wastewater producing industries. It has been assumed for the purposes of this study that these industries (with the exception of the P. H. Glatfelter Company) will, by the year 2000, discharge all of their wastewaters into the municipal systems. For this reason the facilities proposed in each of the Alternatives For Choice have been sized to accommodate both municipal and industrial flows. This is feasible, however, only if the industries, where necessary, pre-treat their wastewaters to remove toxic and other materials not acceptable or amenable to treatment by public facilities. Volume IV of Appendix A presents in detail the volume and nature of the wastewaters to be expected from each existing industry and pre-treatment requirements.

As far as the P. H. Glatfelter Company is concerned, there are two methods by which its wastes could be handled; i.e., either in a separate treatment plant or in combination with a municipal system. Either of these is amenable to the Reuse Option previously discussed.

SLUDGE DISPOSAL

Secondary treatment plants and advanced water process treatment plants produce, as a by-product, a suspended solids residue called sludge. This sludge must be disposed of periodically to permit proper treatment plant operation. Generally, there are two methods for treating and disposing of sludge: incineration and land application. Except for one small treatment plant, all study area treatment plants presently disposed of sludge by applying it to the land. This practice could be continued with any of the Alternatives For Choice. At present, however, the system depends on private agricultural demand for sludge. The Basic All Land Plan, on the other hand, includes areas which would provide all the land needed for sludge disposal.

STORMWATER MANAGEMENT

The Alternatives For Choice, as described, address the problem of improving water quality through the control of municipal and industrial point wastewater discharges. There still remains the problem of water pollution through storm runoff. Storm runoff contains a significant amount of pollutants, specifically phosphorus, BOD, and suspended solids which is collected from such sources as farmland (agricultural runoff) and city streets (urban runoff). To completely harness the pollution problem in the study area will require a management program for stormwater as well as domestic and industrial wastewater.

Appendix A, Volume IV includes an analysis of the urban areas where storm drainage systems exist, namely York, Spring Grove, and Hanover-Penn Township. By considering these as ultimate point discharges of stormwater, it is possible to incorporate them into any of the Alternatives For Choice. The stormwater plan requires storage areas and transmission lines as well as increased sizing of treatment plants. The estimated additional cost is 64 million dollars.

The management of rural area runoff is a complex problem which has not been solved to date. Until more refined techniques and practices can be established, pollution control can be abated only by proper soil conservation practices with the objective of keeping the soil and thus the pollutants in place. Agricultural agencies at the Federal and Commonwealth levels provide technical assistance in these areas.

The main point to be made is that although the Alternatives For Choice will curb domestic and industrial water discharges, the major pollution in the study area, there still remains the problem of stormwater management. The total solution to this is beyond the scope of this study and must come through intensive research and further study.

FRAMEWORK PLAN FOR THE YEAR 2020

One of the initial guidelines of the study was that it consider a planning horizon to the year 2020. In keeping with this, population, wastewater flows, and water supply were all projected to this year. Yet the Alternatives For Choice were all formulated to treat wastewater flows projected to the year 2000. This was done for two major reasons.

First, the needs of the study area, the benefits and costs of the alternatives, and the impacts of the alternatives were able to be identified and expressed with reasonable confidence up to this year. Second, the year 2000 approximated the economic life of the initial wastewater facilities which would be constructed.

To satisfy the initial 2020 guideline, the study proposes a framework to which those implementing the plan can turn for a projection of what facilities would be required

TABLE 14
Framework For The Year 2020
FACILITY DESIGN REQUIREMENTS

SERVICE AREA	WASTEWATER FLOW 2000 (MGD)	WASTEWATER FLOW 2020 (MGD)	FLOW INCREASE (MGD)	LAND REQUIREMENT* INCREASE (ACRES)
York Urban Area	32.4	48.4	16.0	3,114
Hanover-Penn Township	4.7	6.8	2.1	408
Spring Grove	1.5	3.2	1.7	330
Glen Rock-Shrewsbury-New Freedom-Railroad	1.8	3.2	1.4	276
Jacobus-Loganville	0.3	0.8	0.5	97
Seven Valleys	0.07	0.07	-	-
Winterstown	0.03	0.03	-	-
Jefferson	0.04	0.05	0.01	2

*Based on the use of land application.

in the period from 2000 to 2020. With the increased population and wastewater flow in the two decade span, there will be a requirement for enlargement of the pumping stations and subsequent expansion of treatment plants. Work should not have to be done on pipelines, as their size should be adequate to handle the projected flows. Sufficient land exists adjacent to the land disposal areas, save Hanover-Penn Township, to adequately treat 2020 flows. The Hanover-Penn Township service area would require an additional irrigation site away from its present location. Table 16 presents the facility design requirements for the year 2020. Further discussion can be found in Appendix A, Volume IV.

The design requirements of Table 14 are meant only to be an indication of what the year 2020 holds in store for wastewater management in the study area. The figures were derived based on present technological processes. But it would unnecessarily constrain whatever plan is adopted to state that this is what *will* happen by 2020. To do this would negate the flexibility which the study participants have tried to build into the Alternatives For Choice. The framework only says this: that by the year 2020 there probably will be increased wastewater flows which must be treated in some manner and that those managing the system and planning for the future should keep this in mind. More land may not be required; new technonogy may develop which would require less land. Neither this requirement nor any other can be predicted with certainty.

CHAPTER VII FINANCIAL SUPPLEMENT

Introduction

The purpose of this chapter is twofold. First, it shows the sensitivity of the average annual cost of the four alternatives for choice to changes in the assumed rate of interest at which plans would be financed. Secondly, it provides an estimate of the annual local cost to construct, operate, and to maintain a wastewater management system to the year 2000 at varying levels of non-local (Federal plus Commonwealth) cost-sharing.

These data will be useful in providing some general conclusions relative to embarking on a multimillion dollar investment in a wastewater management system.

Total Average Annual Cost-Interest Rate Sensitivity

The current interest rate (often referred to as the discount rate) for evaluation of Federally financed projects is 5 3/8%. Proposals made by the Water Resources Council suggest 7% or 10% may be used in the future. The existing local bond rate is 6%. To demonstrate the effect of a rise in the interest rate on the total average annual cost, Figure 25 shows the total average annual cost of each of the alternatives for choice at each of the four interest rates, viz. 5 3/8%, 6%, 7%, and 10%.

The figure shows that the total average annual costs are very sensitive to change in the interest rate, i.e., cost rises faster than the interest rate. Also, it can be seen that the Basic All Land Plan is more sensitive than the alternatives involving water process treatment. This is so because of the high proportion of total average annual cost that is composed of capital investment (land) costs. Note that at an interest rate of 7.5%, the Basic All Land Plan is equal in total average annual cost to the December Plan. Similarly, at 9%, the Basic All Land Plan has the same total average annual cost as the Basic All Water Plan.

Local Cash Flow at Varying Levels of Non-Local Financing

The total cost of a wastewater management plan will be borne by Federal, Commonwealth, and local agencies. The non-local share is the sum of the funds provided by Federal and Commonwealth agencies. The total cost less the non-local share is the local share.

The non-local share is based on Federal policy stemming from existing legislation, the Commonwealth generally following Federal guidelines. Construction grant programs for wastewater treatment facilities currently offered by the Environmental Protection Agency under the Water Pollution Control Act provide up to 55% of the construction costs, provided the matching State grant is 25%. Thus, the maximum non-local share at present is 80% (55 + 25) and the minimum local share is 20% (100 - 80).

There is reason to believe the local share requirement may be decreased in the near future. Pending legislation in the Congress would provide a Federal grant of up to 75% contingent upon a matching State grant of 15%. In this case the local share would be only 10% (100 - 75 - 15).

On the other hand, it is possible that the current maximum non-local share would not be approved, but that something less would be suggested. For the sake of comparison, assume the non-local share would be 70% of the construction costs (say 50% Federal and 20% Commonwealth). The local share would thus be 30%.

In Figure 26 which follows, local cash flows are shown for each of the three levels of local cost sharing discussed above — 10%, 20%, and 30%. The interest rate is assumed to be 6% and local financing is assumed amortized over a 50 year period. Lastly, the costs used as a basis for computation are averages of those for the three alternatives for choice which attain the adopted water quality standards of the study, namely the Basic All Water Plan, the Basic All Land Plan, and the December Plan.

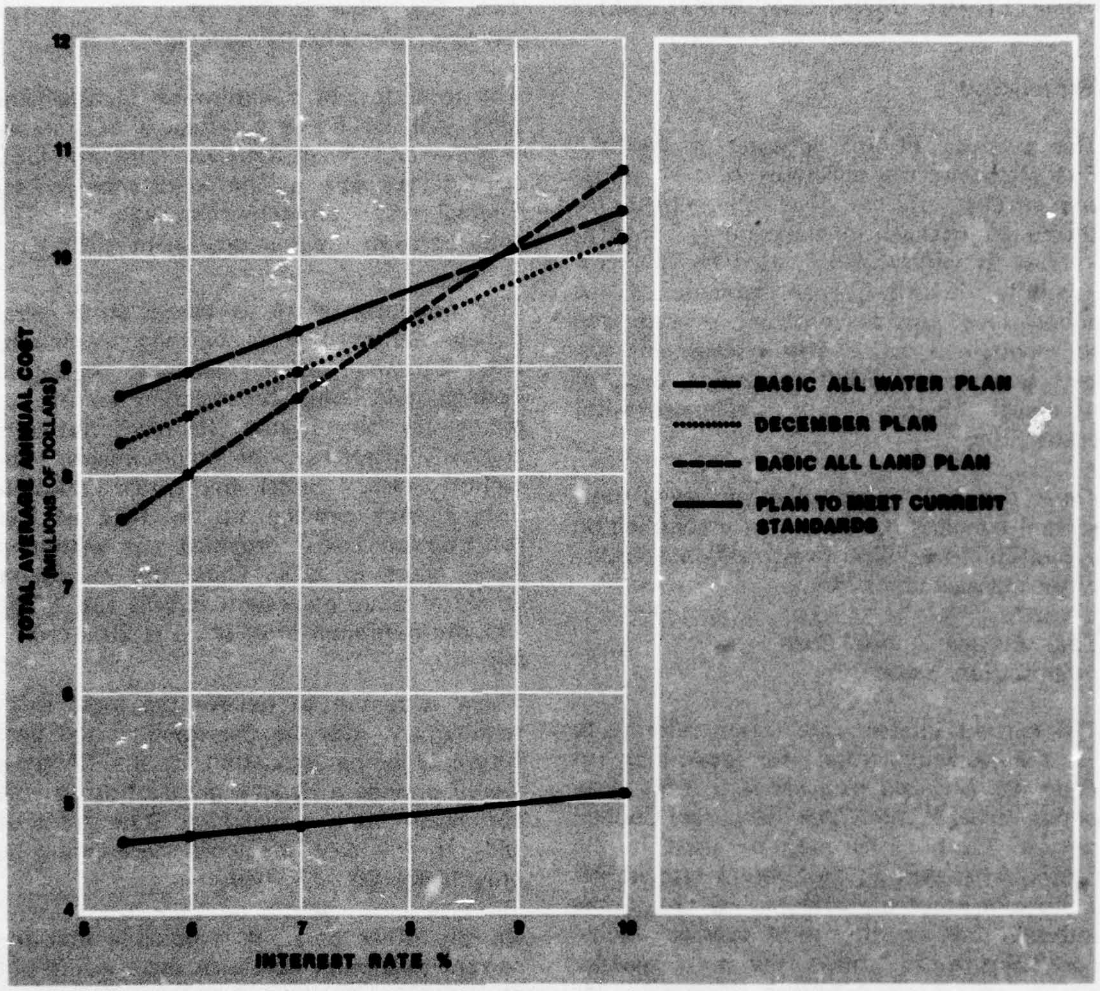


Figure 25. Total Average Annual Cost – Interest Rate Sensitivity

The major conclusion which can be drawn from Figure 26 is that operation and maintenance costs form the bulk of average annual local cash flow. Though an increasing non-local share of construction costs does reduce the annual local cash outflow, the operation and maintenance costs still remain, there being no Federal and limited Commonwealth financial assistance available to ease the burden of this expense.

The superimposed population line indicates that the rising annual local costs will be distributed over a larger rate-paying group. Also, industrial growth, not shown above, is expected and industry should pay a portion of the costs at least commensurate with the rise in these costs.

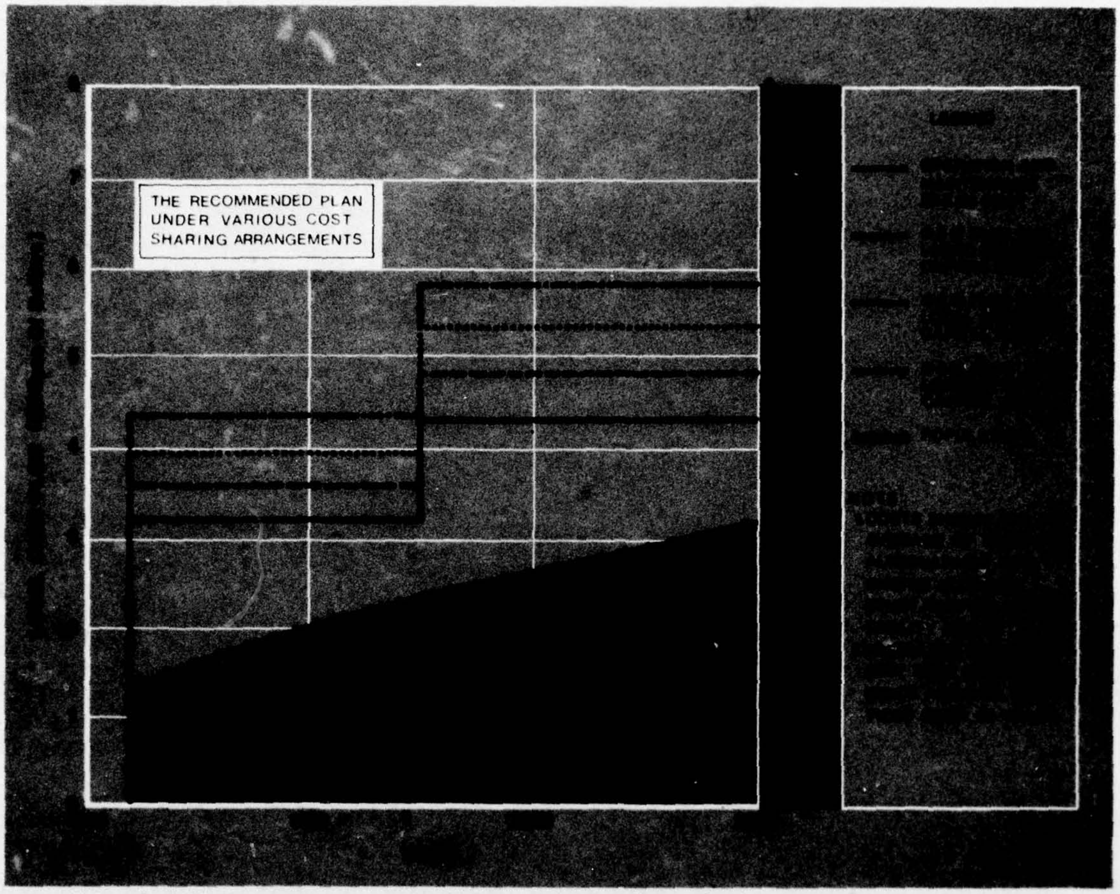


Figure 26. Local Cash Flow Projections

CHAPTER VIII INSTITUTIONAL ALTERNATIVES

Implementation

Based on information developed in Appendix C, "Analysis of Institutional Arrangements," there are four general institutional arrangements through which a regional wastewater management plan could be implemented.

These are:

1. Individual municipal action.
2. Joint municipal action.
3. Formation of municipal authorities below county level.
4. Formation of a county authority.

The first arrangement, individual municipal action, would permit the small communities to proceed at their own pace in wastewater management. The more populated areas, such as the York metropolitan area, would become institutionally muddled as far as wastewater is concerned. The efficiencies already brought about by sub-regional management would be lost; financing arrangements for existing plants and systems would have to be redone; and the program for water quality, from the local, Commonwealth, and Federal viewpoints, would, as a minimum, be temporarily stagnated. While this arrangement is possible, it would be a step backward from the overall situation of today.

As a second possibility, the concerned municipalities could band together in a joint municipal action for wastewater management. Under this arrangement, regional management would be feasible. Drawbacks would be the extensive coordination required and the need for all management positions to be filled out of existing governmental positions. In effect, the overall municipality workload would increase, causing a corresponding increase in personnel and funding. This would be an undesirable arrangement and is not the most efficient means available for wastewater management.

The third method, forming municipal authorities below county level, approximates the existing situation in the study area. It allows for relatively easy financing of major wastewater projects, permits management independent of other municipal governmental functions, and allows for some regionalization.However, the organizational concept of municipal authorities below the county level does not have the potential for maximum effectiveness in wastewater management. Problems which would face these authorities would be extensive coordination, establishment of service areas and procedures for modification, public-private relationships and agreements, repayment of existing debt and acquisition and equity distribution of new debt, and overall regional management of the system through fragmented control.

The fourth method, a county wastewater authority, would provide central direction and control of wastewater management, assure representation to the municipalities served, and implement a regional solution to the wastewater problems of the study area. A county authority would be established by joint municipal action under the Municipality Authorities Act to: outline the transition from the several existing authorities with their assets and liabilities to one authority with consolidated assets and liabilities; apply for construction grants through the appropriate Commonwealth and Federal agencies; and establish an actual management structure and operating procedure for the regional wastewater system. The county authority would be able to view the study area as a region composed of a stream system, municipalities, and wastewater service areas. It would be able to see them as interdependent, not independent. It would also be better able to interact with other regional programs and plans such as economic growth and development, land use management, solid waste management, and air quality management.

A county authority also would face difficult problems. Consolidation of numerous local wastewater programs into a regional county system is not yet common in the nation and there are no clear rules to follow. The

engineering design and construction effort required will be complex, requiring much time and study. If wastewater reuse is adopted as an option, an effective and equitable public-private arrangement would have to be derived.

Acquiring and Utilizing Land for Land Application Treatment

The land component of any land application wastewater disposal system will be used for three purposes: (1) to dispose of treated effluent; (2) to reclaim purified wastewater; and (3) to cultivate and harvest crops. Before it can be used for these purposes, it must come under the control of the managing wastewater institution so that it can be managed to insure that these functions are performed in an optimal manner.

There are three basic options open to a wastewater management agency by which it may acquire the use of land for land application.

These are:

1. Purchase
2. Lease
3. Easement or permit

Purchase is the simplest solution available. All rights to the land are transferred to the management agency and it may proceed with system implementation and operation with the greatest freedom of action. However, land ownership is then removed from the private sector. Local income which was formerly received from taxes on the land will no longer exist. Income generated by the productivity of the land may still provide a tax revenue, depending on the farming arrangements made by the management agency. Purchase will probably require some relocation of households and farmsteads and will likely cause a shift in rural residential patterns.

The second option is to lease the land. The wastewater management agency would in essence become a tenant. Consequently, the property tax base would remain undisturbed, the owner still retaining title to the land. On the other hand, agency control of the land is not as flexible as it was under the purchase option. As with the purchase option, tax generated by land productivity will depend on farming arrangements. Lease will also probably require some relocation of households and farmsteads and will likely cause a shift in rural residential patterns.

The third option is easement or permit. The management agency would obtain permission to do only specific things with the land, e.g. lay irrigation piping, install drainage systems, and irrigate the land with treated effluent. From the point of view of the management agency, it is the most restrictive of the options. On the other hand, the property would remain in the private sector, there would be little change in tax revenue from land productivity, and there would be little relocation and thus minor change in rural residential patterns.

In overview of these three options — purchase, lease, and easement or permit — there is an evident tradeoff between facilitation of system management and minimization of negative impacts. The task is thus to find the compromise position which will satisfy both concerns.

With both the purchase and lease options, management of crop cultivation and harvest can be accomplished either with agency employees or by contract to private firms or individuals. Under the easement or permit option, cropping would probably be done by the landowner, in cooperation with the management agency. The method of land acquisition will in great part determine the method of cropping.

In summary, the land application technology will require the acquisition and utilization of land. It may, but need not have to, change existing conditions in the regions where land is required, particularly in the areas of private vs public ownership, tax revenues, and rural residential patterns. Done carefully, there can be both negligible adverse impacts and effective system control.

CHAPTER IX CONCLUSIONS

Plan Selection

In order to obtain a water quality plan for the Codorus Basin Study area, two major decisions are required. These decisions, which determine the path from polluted water to clean water (whether to the study adopted water quality goals or to current standards) are (1) the choice of a plan and (2) the desirability of the Reuse Option. The process by which these decisions are made is straightforward, but will require careful and thoughtful attention to execute. An inherent part of the process is the selection of a plan from among the alternatives for choice. Facilitating selection are premise sets leading to a conclusion as to the plan best responding to the premises.

The Codorus Creek Wastewater Management Study has developed four plans, three of which attain the study adopted water quality goal (Class D or F treatment) and the study objective of a significant improvement in the quality of Codorus Creek. The fourth plan meets less stringent current water quality standards and achieves a water quality improvement somewhat less than the other three. Presented below, for each of the four alternatives for choice, are a set of premises which, if accepted, support its selection as the plan for implementation. A fifth premise set, if accepted, supports the Reuse Option.

PREMISE SET ONE: If the positions are held that –

1. The increase of benefits of the study adopted water quality goals over the existing standards cannot justify the cost of such an increase; and
2. The basic status quo for wastewater treatment should be maintained; then

CONCLUSION ONE: The best plan is the Plan to Meet Current Standards.

PREMISE SET TWO: If the positions are held that –

1. The study's adopted water quality goals must be attained; and
2. The study area's existing wastewater treatment facilities must not be abandoned, even if abandonment would have an economic advantage; and
3. The adopted plan should have minimum land requirements; and
4. Uncertainties due to lack of knowledge relative to land application systems are sufficient reasons to reject this concept; then

CONCLUSION TWO: The best plan is the Basic All Water Plan.

PREMISE SET THREE: If the positions are held that –

1. The study's adopted water quality goals must be obtained; and
2. A substantial cost saving is sufficient justification for abandoning the study area's existing treatment facilities; and
3. Enhancement of the region's future water supply availability by increasing headwater drought flows is a relevant benefit from a wastewater management system; and
4. There is an advantage to implementing a plan with potential agricultural benefits; and
5. A wastewater management plan should best complement other environmental programs; and
6. The preservation of open space should be a consideration in any plan for the Codorus Creek Basin; and
7. The recommended plan should combine least cost with the most effective technical performance; and
8. Departure from the basic status quo in wastewater treatment to land application is acceptable; then

CONCLUSION THREE: The best plan is the Basic All Land Plan.

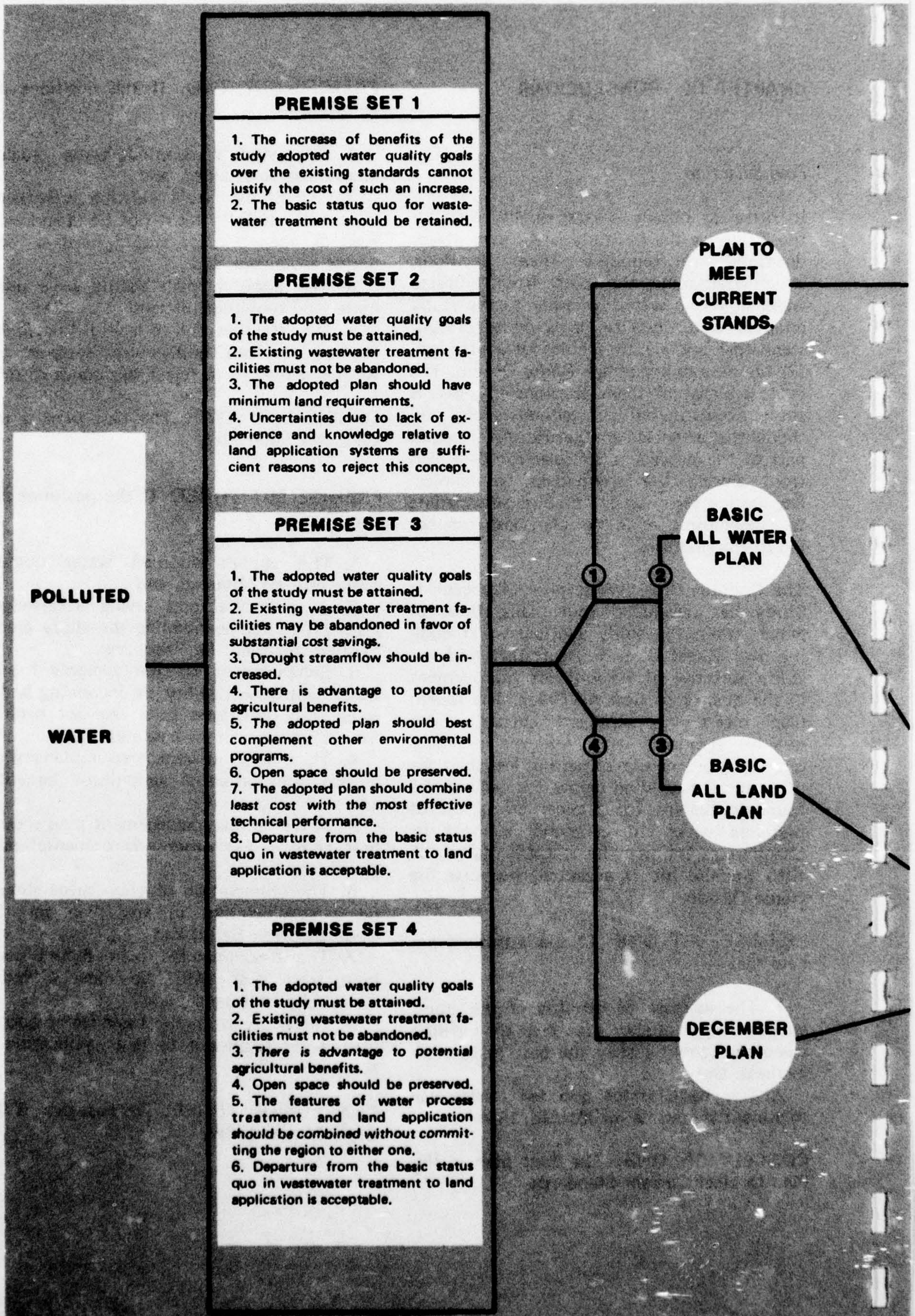
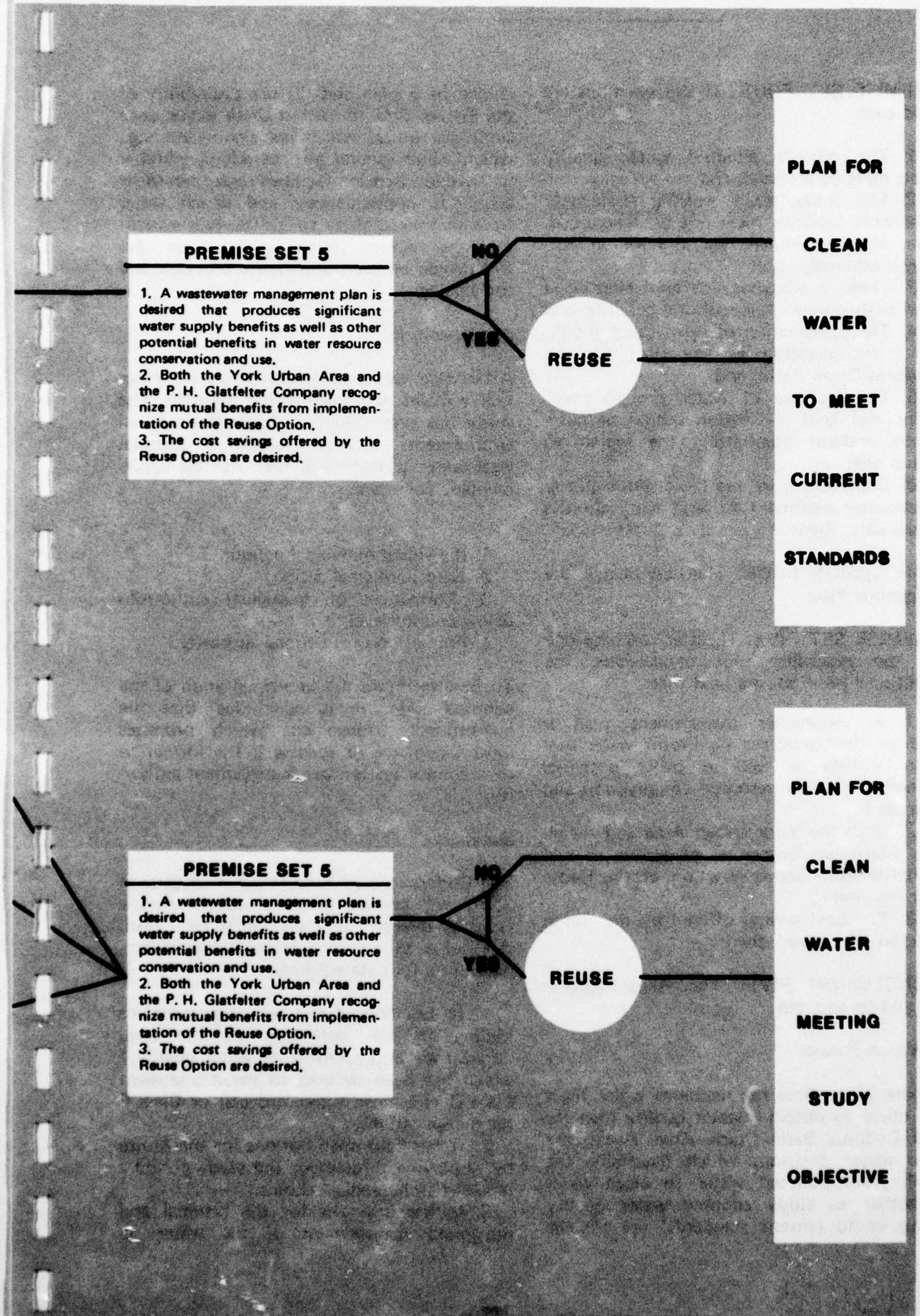


Figure 27. Required Decision Process


PREMISE SET 5
1. A wastewater management plan is desired that produces significant water supply benefits as well as other potential benefits in water resource conservation and use.
2. Both the York Urban Area and the P. H. Glatfelter Company recognize mutual benefits from implementation of the Reuse Option.
3. The cost savings offered by the Reuse Option are desired.
NO
YES
REUSE
PLAN FOR CLEAN WATER TO MEET CURRENT STANDARDS
PREMISE SET 5
1. A wastewater management plan is desired that produces significant water supply benefits as well as other potential benefits in water resource conservation and use.
2. Both the York Urban Area and the P. H. Glatfelter Company recognize mutual benefits from implementation of the Reuse Option.
3. The cost savings offered by the Reuse Option are desired.
NO
YES
REUSE
PLAN FOR CLEAN WATER MEETING STUDY OBJECTIVE

PREMISE SET FOUR: If the positions are held that:

1. The study's adopted water quality goals must be attained; and
2. The study area's existing wastewater treatment facilities must not be abandoned, even if abandonment would have an economic advantage; and
3. There is advantage to implementing a plan with potential agricultural benefits; and
4. The preservation of open space should be a consideration in any plan for the Codorus Creek Basin; and
5. The features of water process treatment and land application should be combined without committing the region to either one; and
6. Departure from the basic status quo in wastewater treatment to land application is acceptable; then

CONCLUSION FOUR: The best plan is the December Plan.

PREMISE SET FIVE: If, after reaching one of the preceding four conclusions, the additional positions are held that:

1. A wastewater management plan is desired that produces significant water supply benefits as well as other potential benefits in water resource conservation and use; and
2. Both the York Urban Area and the P. H. Glatfelter Company recognize mutual benefits from implementation of the Reuse Option; and
3. The cost savings offered by the Reuse Option are desired; then

CONCLUSION FIVE: The Reuse Option should be adopted.

Decision Process

Figure 27 outlines the decisions which must be made to obtain a water quality plan for the Codorus Basin Study Area. Again, the two major decisions which determine the path from polluted water to clean water (whether to study adopted water quality goals or to current standards) are (1) the choice of a plan and (2) the desirability of the Reuse Option. Within these major decisions are others which are significant, e.g., which water quality goal to adopt, whether to abandon existing facilities regardless of its economic consequences, and which water treatment technology to utilize. It is evident that the decision process facing those who will decide on plan selection is complex and challenging.

Implementation

After plan selection is complete, a further task remains of implementing the plan. The study has presented four basic institutional arrangements through which a regional wastewater management plan can be implemented. These are:

1. Individual municipal action;
2. Joint municipal action;
3. Formation of municipal authorities below county level;
4. Formation of a county authority.

To best facilitate the implementation of the adopted plan, it is concluded that the institutional arrangement which promises most likelihood of success is the formation of a county wastewater management authority.

Summary

The Codorus Creek Wastewater Management Study will prepare decision makers for the tasks of selecting and implementing a plan. It is able to do so because it has accomplished its four stated goals:

1. It has formulated technical solutions leading to the definition of the term "significant improvement of water quality," which has been defined to mean treatment Class D (advanced water process) or Class F (land application).
2. It has kept open options for the future by displaying throughout the study period a range of technological choice.
3. It has provided for the rational and integrated management of the water re-

sources of the Codorus Basin.

4. It has designed implementable solutions.

With the satisfaction of the study's four goals, the objective of the study has consequently been attained. This volume, together with the companion volume, *Findings of Fact and Recommendations*, presents and recommends those actions which are necessary to significantly improve the quality of the waters of the creek to the extent that they can provide a basis for the restoration of natural environmental values while simultaneously serving the economic and social needs of the people.

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CHAPTER X CREDITS AND ACKNOWLEDGEMENTS

This report was prepared by the Baltimore District, Corps of Engineers, under the general direction of Colonel Louis W. Prentiss, Jr., District Engineer.

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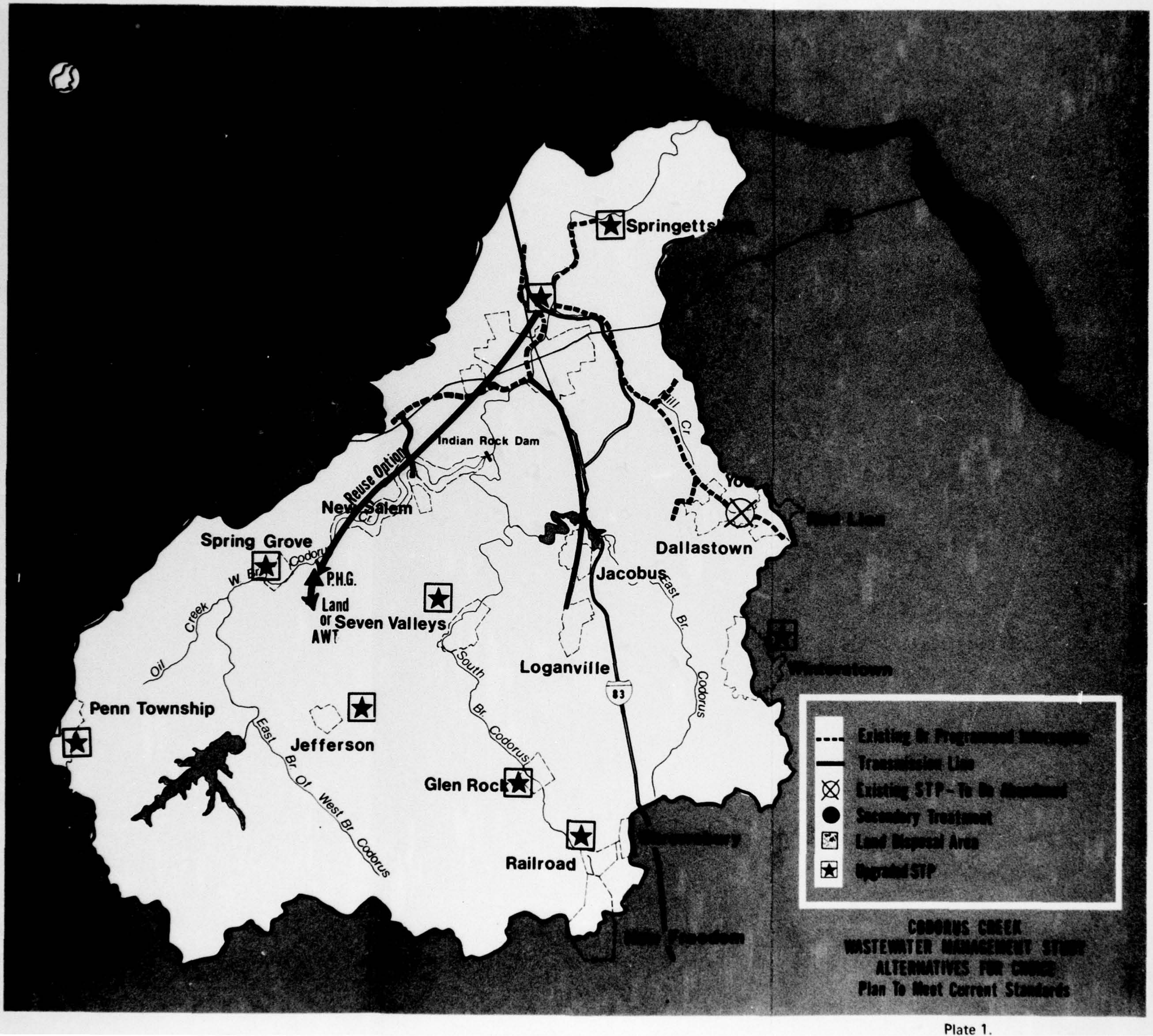
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Seven Valleys
Dallastown
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83
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Penn Township
Jefferson
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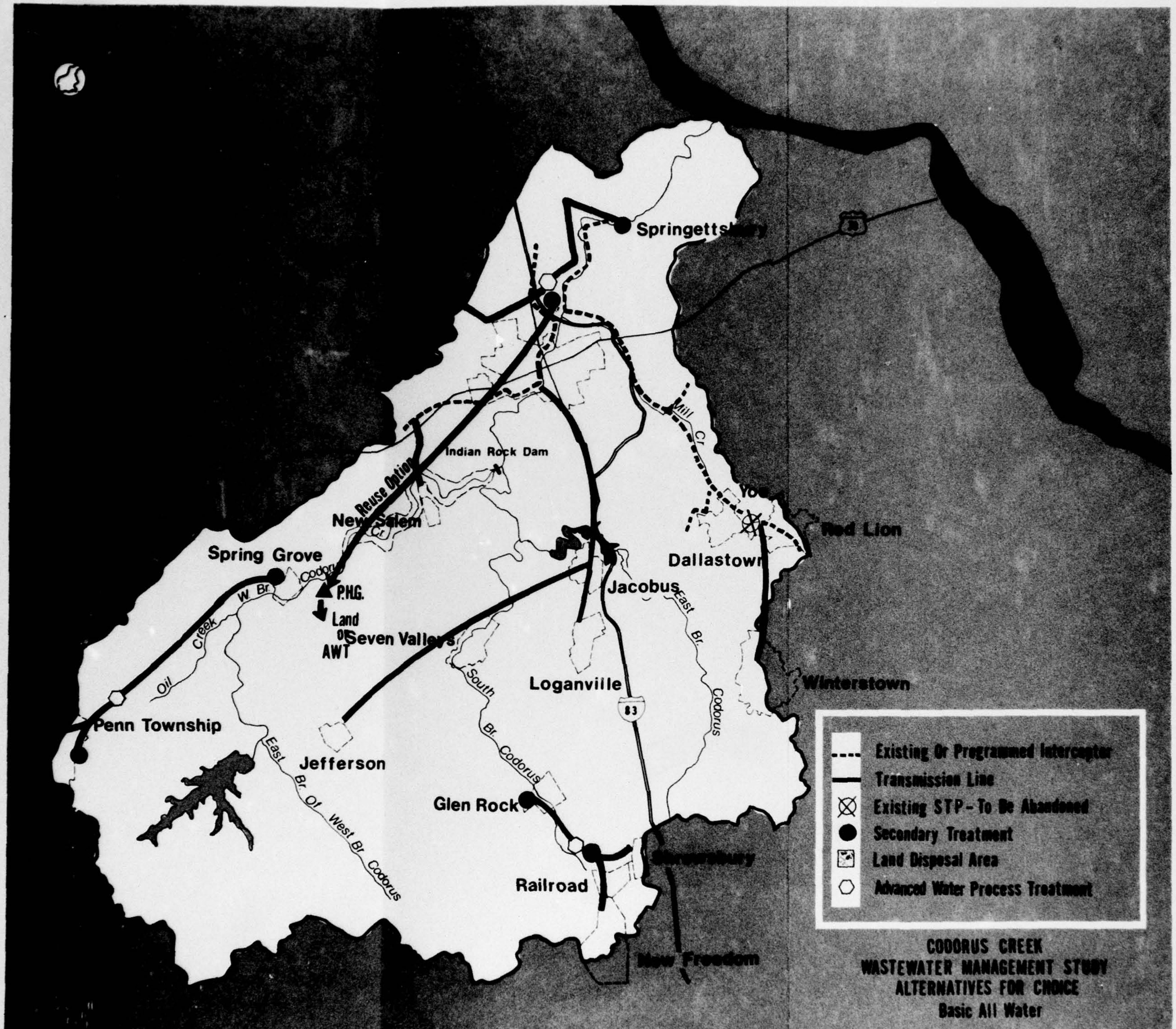
West Br
Codorus
Glen Rock
Railroad
Transmission Line
Secondary Treatment
Land Disposal Area
Upgraded STP
CODORUS CREEK
WASTEWATER MANAGEMENT STUDY
Plan To Meet Current Standards

Plate 1.



Existing Or Programmed Interceptor
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Advanced Water Process Treatment
CODORUS CREEK
WASTEWATER MANAGEMENT STUDY
ALTERNATIVES FOR CHOICE
Basic All Water
Indian Rock Dam
Reuse Option
Spring Grove
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Dallastown
Red Lion
Winterstown
Loganville
Penn Township
Jefferson
Glen Rock
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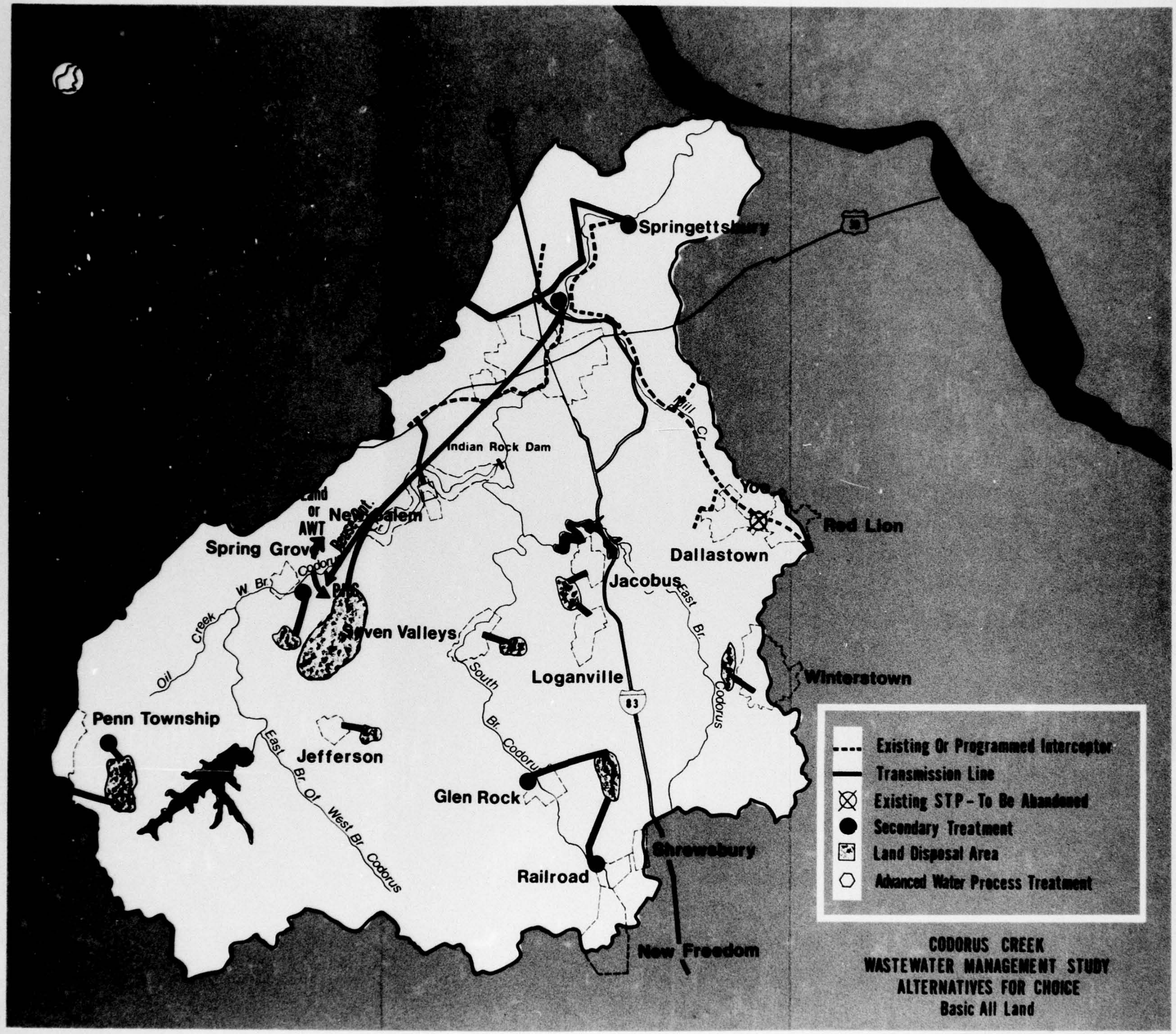
Plate 2.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30
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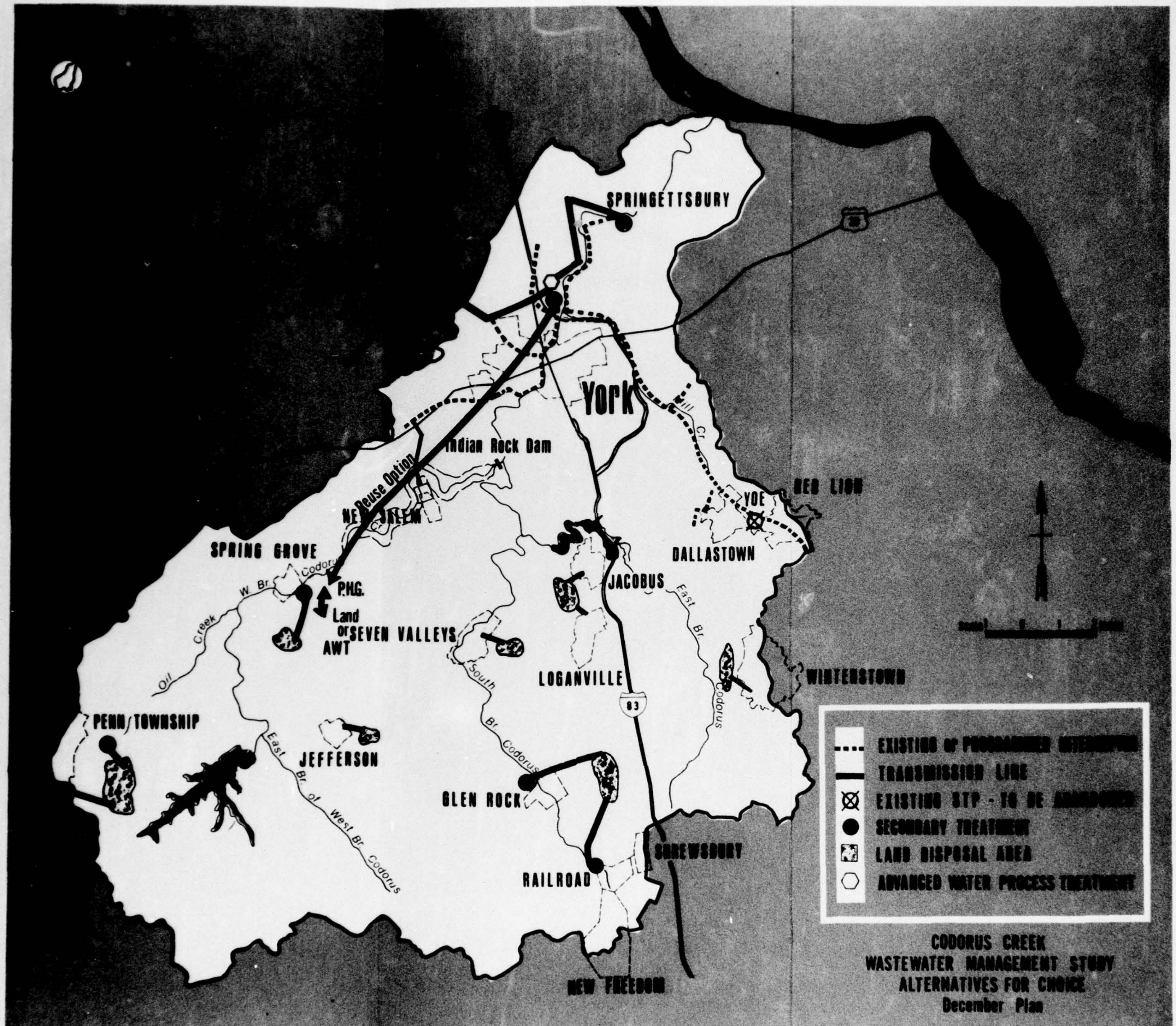
CODORUS CREEK
WASTEWATER MANAGEMENT STUDY
ALTERNATIVES FOR CHOICE
Basic All Land

Plate 3.


SPRINGETTSBURY
York
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SPRING GROVE
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LOGANVILLE
JACOBUS
DALLASTOWN
YOE
RED LION
WINTERSTOWN
East Br. Codorus
GLEN ROCK
RAILROAD
SHREWSBURY
NEW FREEDOM
83
TRANSMISSION LINE
SECONDARY TREATMENT
LAND DISPOSAL AREA
ADVANCED WATER PROCESS TREATMENT
CODORUS CREEK
WASTEWATER MANAGEMENT STUDY
ALTERNATIVES FOR CHOICE
December Plan

Plate 4.

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